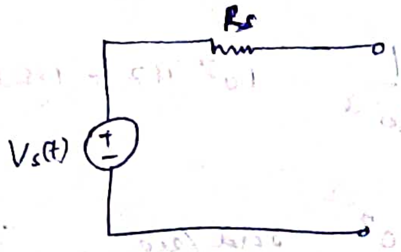
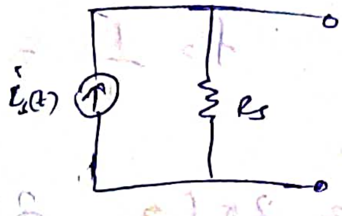
(1)

Exercises :- Sedra, Smith

1.1



(a)



(b)

Q → (a) What are the open-ckt o/p voltage that would be observed.

For each o/p terminal short ckted,

(b) → what current would flow?

(c) For the representation to be equivalent, what must the relationship betn V_s, i_s & R_s.

V	I
For (a) $V_{oc} = V_s(t)$	**For (a)** $I_{sc} = \frac{V_s(t)}{R_s}$
For (b) $V_{oc} = R_s \cdot i_s(t)$	**For (b)** $I_{sc} = i_s(t)$

Ans ÷ For equivalency $V_s(t) = R_s \cdot i_s(t)$.

1.2. A signal source has an open ckt voltage 10 mV & s.c. current 10 μA. What is the source resistance

Ans :- $R_s = \frac{V_{oc}}{I_{sc}} = \frac{10 \times 10^{-3}}{10 \times 10^{-6}} = 10^3 \Omega = 1 k\Omega$

1.3. Find the frequency f & ω of a [redacted] sine wave signal with period of 1 ms.

$T = 1ms = 10^{-3}$ sec.

$f = \frac{1}{T} = \frac{1}{10^{-3}} = 10^3$ Hz $= 1$ KHz.

$\omega = 2\pi f = 2\pi \times 10^3$ rad/sec.

1.4) What is the the period T of sine waveforms characterized by freq of

(a) $f = 60$ Hz →

(b) $f = 10^{-3}$ Hz. →

(c) $f_0 = 1$ MHz. →

$T = \frac{1}{60} = 0.016 = \frac{0.0167 \times 10^{-3}}{10^{-3}} = 16.7$ ms.

$T = \frac{1}{10^{-3}} = 10^3$ sec ~~1 Hz~~ = 1000 sec.

$T = \frac{1}{10^6} = 10^{-6}$ sec = 1 μs.

1.5// The UHF (Ultra High freq) television broadcast band begins with channel 14 & extends from 470 MHz to 806 MHz. If 6 MHz is allocated for each channel, how many channels can this band accomodate.

Ans: $\frac{806 - 470}{6} = \frac{336}{6} = 56$ channel.. (a)

Channels 14 to (14+56)−1

14 to (70−1)

14 to 69 (b)

(1)

(1.6)

1.7 Consider a 4 bit digital word $D = b_3 b_2 b_1 b_0$ used to represent an analog signal V_A that varies between 0V to +15 V.

(a) Give D corresponding to V_A = 0 V, 1V, 2V, 15V

(b) What change in V_A causes a change from 0 to 1 in (i) b_0 (ii) b_1 (iii) b_2 (iv) b_3?

(c) If ~~V_A = 2.5~~ V_A = 5.2 V, what do you expect D to be? What is the resulting error representation.

Ans: (a) → 0 → 0000

→ 2 | 1, 0 → 1 → 0001

→ 2 | 2, 2 | 1 → 0, 0 → 1 → 0010

→ 2 | 15, 2 | 7 → 1, 2 | 3 → 1, 2 | 1 → 1, 0 → 1 → 1111

(b) 0000 → 0

→ 0001 → 1 → 1V

→ 0010 → 2 → 2V

→ 0100 → 4 → 4V

1000 → 8 → 8V

c/

5.2 ✓

5 → 0101

error → $\frac{5-5.2}{5} \times 100 = \frac{-20}{5} = -4\%$

Example 1.1

Consider an amplifier operating from ±10V power supplies. It is fed with sinusoidal voltage having 1V peak & delivers a sinusoidal voltage o/p 9V peak to 1kΩ load. The amplifier draws a current of 9.5 mA from each of its 2 power supplies. The i/p current of the amplifier is found to be sinusoidal with 0.1mA peak. Find the voltage gain, current gain, power gain & power drawn from dc supplies, power dissipated in the amplifier and the amplifier efficiency.

Ans: (a) $A_v = \frac{9}{1} = 9$

$A_v = 20\log 9 = 20\log 3^2$

$= 40\log 3$

~~= 40 × .4010~~

$= 40 \times .4771$

$A_v = 19.08$ dB

log2 = .3010
log3 = .4771
log5 = .698

(b) $A_I = \frac{I_o}{I_i}$

$I_o = \frac{9V}{1k\Omega} = 9mA$.

$A_I = \frac{9 mA}{0.1 mA} = 90$.

$A_I = 20 \log 90 = 39.1 dB$

(c) $P_L = V_{orms} \, I_{orms} = \frac{9V}{\sqrt{2}} \times \frac{9mA}{\sqrt{2}} = \frac{81}{2} = 40.5 mW$.

$P_I = V_{irms} \, I_{irms} = \frac{1}{\sqrt{2}} \times \frac{0.1 mA}{\sqrt{2}} = \frac{0.1}{2} = .05 mW$.

$A_P = \frac{40.5}{.05} = \frac{4050}{5} = 810$.

$A_P = 10 \log 810 = 29.1 dB$.

(d) <u>Power drawn</u>, $P_{dc} = 10 \times 9.5 + 10 \times 9.5$

$= 2 \times 10 \times 9.5$

$= 2 \times 95$

$= 190 mW$.

$P_{dissipated} = P_{dc} + P_I - P_L$

$= 190 + 0.05 - 40.5$

$= 149.55$

$= 149.6 mW$.

(e) $\eta = \frac{P_L}{P_{dc}} = \frac{40.5}{190} \times 100 = 21.3 \%$.

0

Ex-1.2:

A transistor amplifier has the transfer characteristics

$$V_o = 10 - 10^{-11} e^{40 V_I} \quad \text{—— (i)}$$

which applies for $V_I \geq 0$ & $V_O \geq 0.3V$.

Find the limits L_- & L_+ & corresponding values of V_I. Also find the value of dc bias voltage V_I that results in $V_O = 5V$ & voltage gain at corresponding operating point.

Ans: The limit L_- is obviously $0.3V$.

The corresponding value V_I obtained by substituting $V_O = 0.3V$, in eqn (i)

$$V_O = 10 - 10^{-11} e^{40V_I}$$

$$\Rightarrow 0.3 = 10 - 10^{-11} e^{40V_I}$$

$$\Rightarrow 10^{-11} e^{40V_I} = 9.7$$

$$\Rightarrow e^{40V_I} = \frac{9.7}{10^{-11}}$$

$$\Rightarrow 40V_I = \ln\left(\frac{9.7}{10^{-11}}\right)$$

$$\Rightarrow V_I = \frac{27.60}{40} = 0.690$$

L_+, determined by $V_I = 0$,

$$L_+ = 10 - 10^{-11} \cdot 1 \simeq 10.$$

To bias the device so that $V_O = 5V$, we require V_I whose value is obtained by

Substituting $v_O = 5V$

$$v_O = 10 - 10^{-11} e^{40 v_I}$$

$$\Rightarrow 5 = 10 - 10^{-11} \cdot e^{40 v_I}$$

$$\Rightarrow 5 = 10^{-11} e^{40 v_I}$$

$$\Rightarrow e^{40 v_I} = \frac{5}{10^{-11}} = 5 \times 10^{11}$$

$$\Rightarrow 40 v_I = \ln(5 \times 10^{11})$$

$$\Rightarrow v_I = \frac{\ln(5 \times 10^{11})}{40} = 0.673 \ v.$$

→ The gain at the operating point is obtained by evaluating the derivative $\frac{dv_O}{dv_I}$ at $v_I = 0.673$ V.

$$v_O = 10 - 10^{-11} e^{40 v_I}$$

$$\Rightarrow \left.\frac{dv_O}{dv_I}\right]_{0.673} = 10^{-11} \cdot e^{40 v_I} \cdot 40.$$

$$= 10^{-11} \times e^{40 \times (0.673)} \times 40$$

$$= 10^{-11} \times 4.91 \times 10^{11} \times 40$$

$$= 196.4$$

$$\boxed{A_v \simeq 200} \ V/V.$$

Exercise

1.8. An amplifier has a voltage gain of $100 \frac{V}{V}$ & current gain 1000 A/A. Express voltage & current gain in dB & find the power gain.

Ans :

$A_V = 20 \log 100$

$= 20 \times 2$

$A_V = 40\ dB$

$A_I = 20 \log 1000$

$= 20 \times 3$

$A_I = 60\ dB$

$A_P = A_V \times A_I$

$= 100 \times 1000$

$= 10^5$

$A_P = 10 \log 10^5$

$= 5 \times 10$

$A_P = 50\ dB$

BPUT - 2008

2/ An amplifier operating from ± 3V supplies provides a 2.2 Vpeak sine wave across a 100Ω load, when provided with 0.2V peak input from which 1.0 mA peak is drawn. The avg. current in each supply is measured to be 20 mA. Find the voltage gain, current gain & power gain expressed as ratios in dB as well as supply power, amplifier dissipation & amplifier efficiency.

Ans :-

Voltage gain $= \dfrac{\text{o/p voltage}}{\text{i/p voltage}}$

$= \dfrac{2.2}{0.2}$

$= \dfrac{22}{2}$

$A_V = \boxed{11}$

In dB $= 20 \log 11 = \boxed{20.827 \text{ dB.}}$

Current gain $(A_I) = \dfrac{\text{o/p current}}{\text{i/p current}}$

o/p current $= \dfrac{\text{o/p voltage}}{\text{o/p load resistance}} = \dfrac{2.2}{100} = .022 \text{ Amp}$

$= 22 \text{ mA}.$

$A_I = \dfrac{\text{o/p current}}{\text{i/p current}} = \dfrac{22 \text{ mA}}{1.0 \text{ mA}} = \boxed{22}$

A_I in dB $= 20 \log 22 = \boxed{26.848} \text{ dB}$

A_P = Power gain $= \dfrac{\text{o/p power}}{\text{i/p power}}$

o/p power $= V_{orms} \cdot I_{orms} = \dfrac{2.2}{\sqrt{2}} \times \dfrac{22 \text{ mA}}{\sqrt{2}}$

$= 24.2 \text{ mwatt.}$

i/p power $= V_{irms} \times I_{irms}$

$= \dfrac{0.2}{\sqrt{2}} \times \dfrac{1 \text{ mA}}{\sqrt{2}} = 0.1 \text{ mwatt}$

$$A_P = \frac{24.2}{0.1} = \left(\frac{O/P\ power}{I/P\ power}\right)$$

$$= 242$$

$$(A_P)_{dB} = 10 \log 242 = \boxed{23.838}$$

Supply power

$$P_{dc} = 3 \times 20\ mA + 3 \times 20\ mA$$

$$= 120\ mwatt$$

$$\boxed{P_{dc} = 0.12\ watt}$$

$$P_{dissipated} = \text{supply power} + \text{I/P power} - \text{O/P power}$$

$$= 120 + 0.1 - 24.2$$

$$\boxed{P_{dissipated} = 95.9\ mwatt}$$

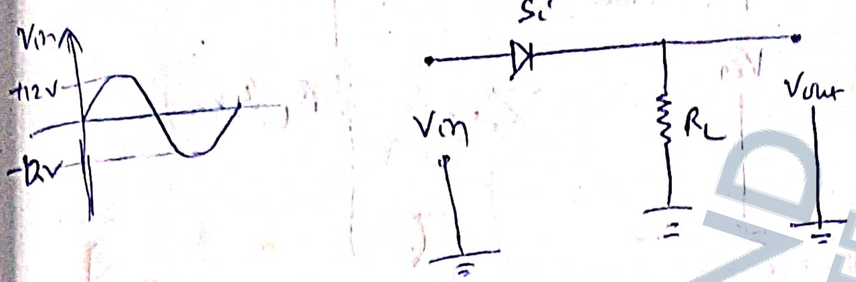
Amplifier efficiency

$$(\eta) = \frac{O/P\ power}{supply\ power} = \frac{24.2}{120} = .2016$$

$$\boxed{\eta = 20.16\ \%}$$

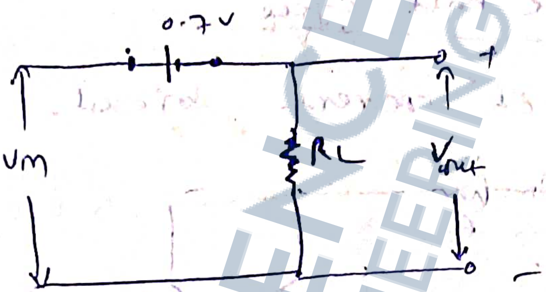
Clipper :-

1) For -ve series clipper shown in fig (1), what is the peak O/P voltage from the ckt?



Ans :- During +ve half cycle, →

$(V_{in} > 0.7V)$



$V_{in} < 0.7$

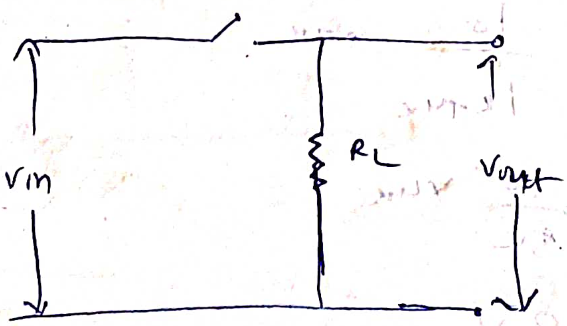
Diode reverse biased, ~~O/P~~ = open circuit, O/P = 0.

The diode is forward biased. The voltage drop across the diode is 0.7V.

$$V_{in} - 0.7 - V_{out} = 0$$

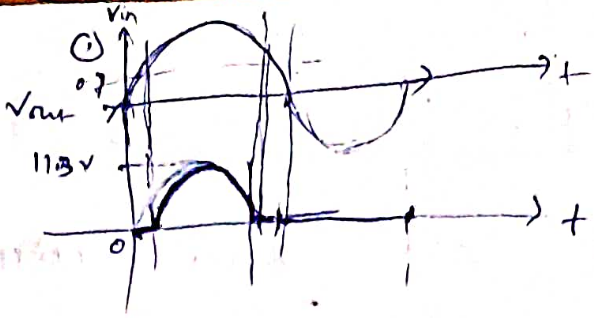
$$\Rightarrow V_{out} = V_{in} - 0.7 = 12 - 0.7 = 11.3V.$$

During -ve half cycle :-



The diode is reverse biased. It act as a open ckt. O/P is zero.

∴ V_{out} is



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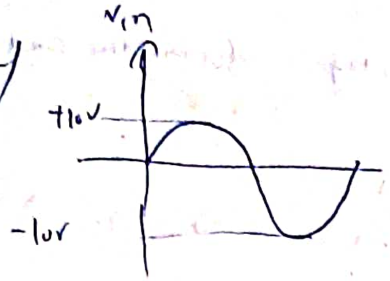
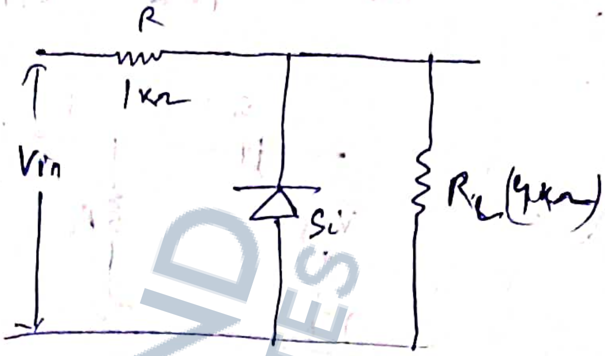
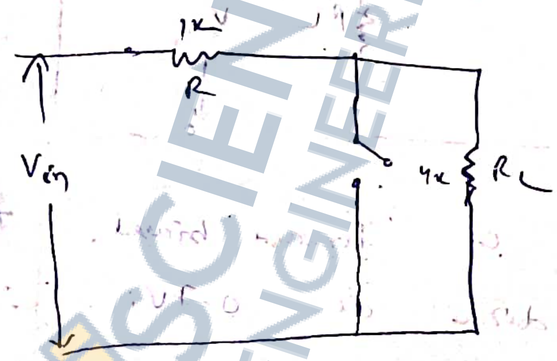




Find the o/p voltage waveform.

Ans: During +ve half cycle

The diode is reverse biased.



$$V_{out} = I \times R_L$$

$$= \frac{V_{in}}{R + R_L} \times R_L$$

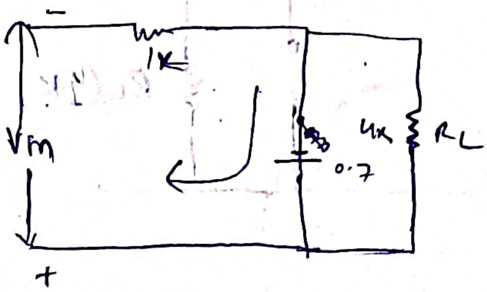
$$= \frac{10}{1k + 4k} \times 4k$$

$$= \frac{10}{5k} \times 4k$$

$$V_{out} = 8\ V$$

During −ve half cycle

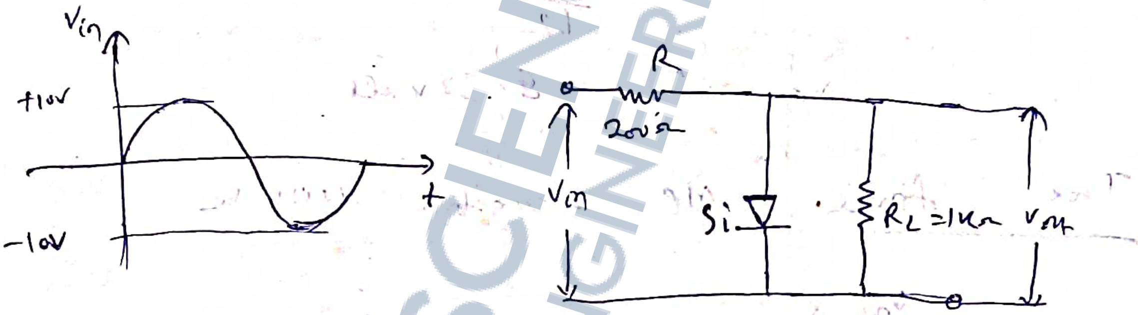
The diode is forward biased.



The o/p across Load is −0.7V.

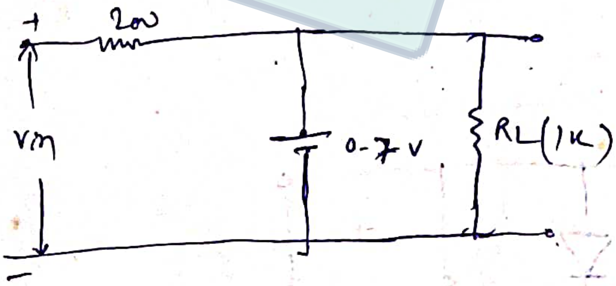
∴ Final o/p voltage waveform will be

3)



What is the o/p ?

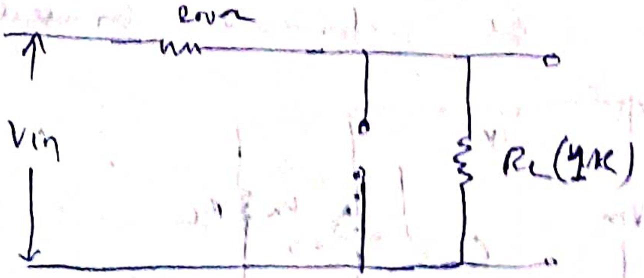
During +ve half cycle:



The diode is forward biased.

$V_{out} = 0.7V$

During -ve half cycle



$$V_{out} = I \times R_L$$

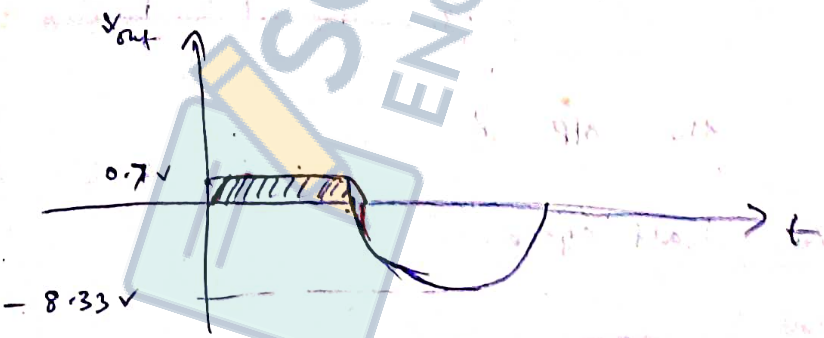
$$= \frac{V_{in}}{200 + 1000} \times 1000$$

$$= \frac{-10}{1200} \times 1000$$

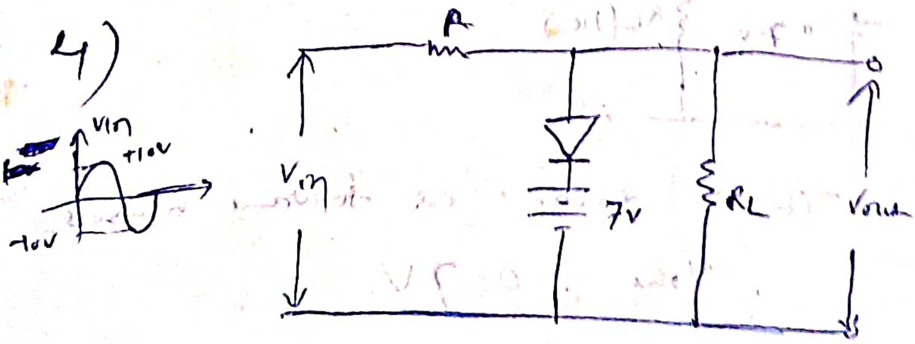
$$= \frac{-100}{12}$$

$$V_{out} = -8.33 \text{ volt}$$

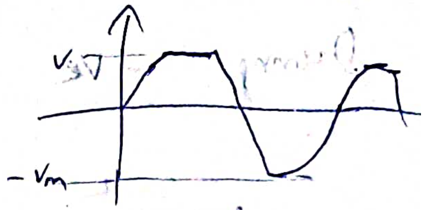
The final o/p waveform will be

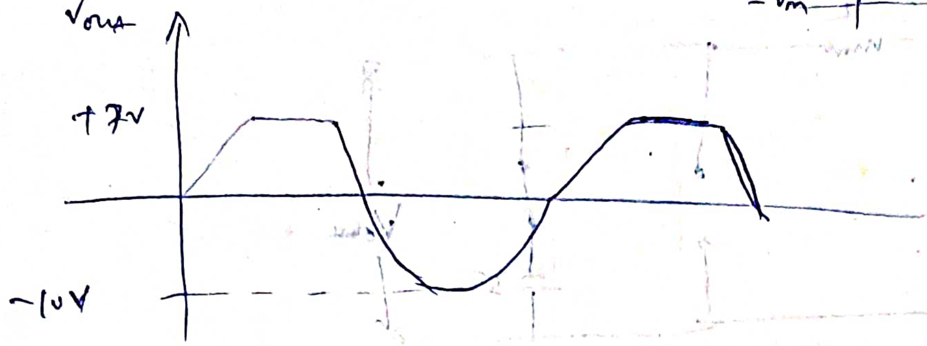


4)

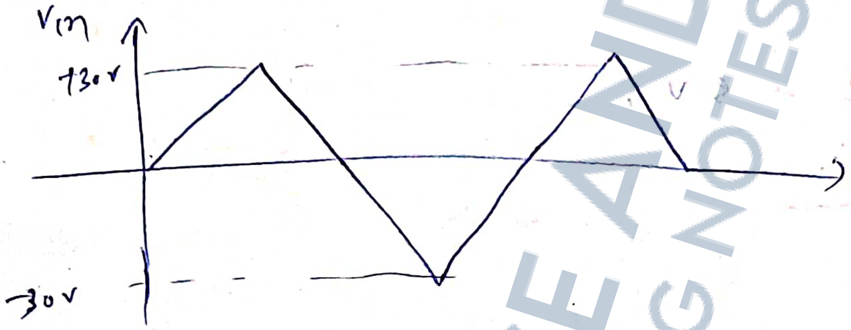


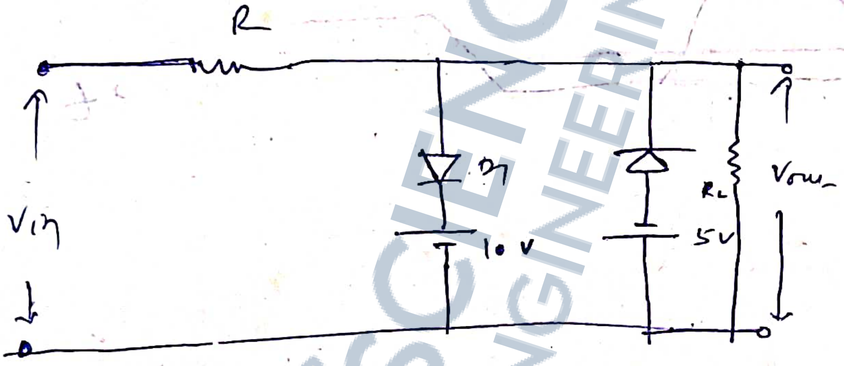
+ve biased clipper





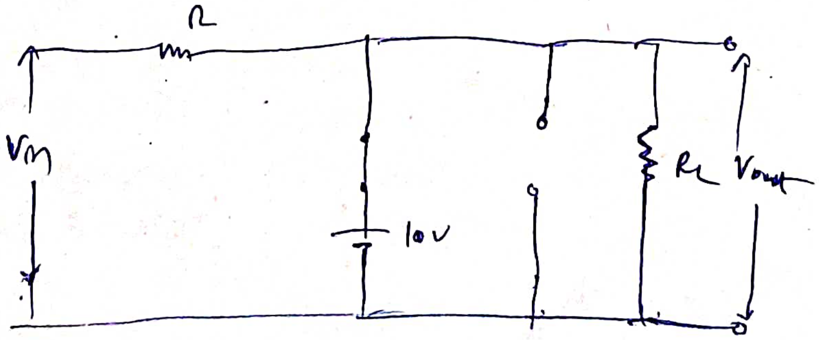
5)





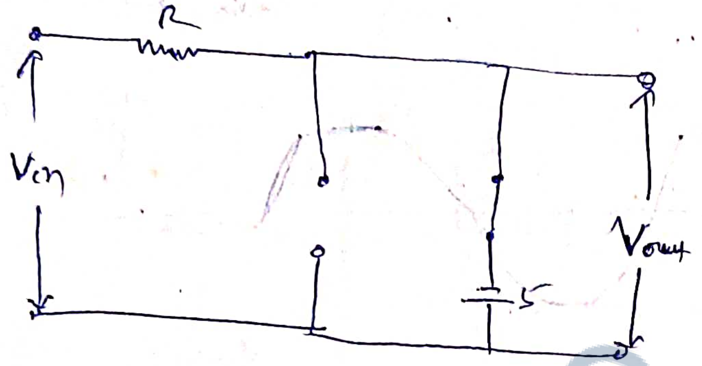
? ?

Ans: During +ve half cycle D_1 is forward biased and D_2 is Reverse biased.



$V_{out} = +10V$.

During -ve half-cycle (D_1 is reverse biased, D_2 is forward biased)



$V_{out} = -5V$.

Final waveform

79. A silicon diode said to be 1 mA device displays a forward voltage of 0.7 V, at current of 1 mA. Evaluate the junction scalaling constant I_S in the event when $n = 1$ or 2.

Ans :-

$$I_D = I_S \left(e^{V_D/\eta V_T} - 1\right)$$

$$I_D \simeq I_S \left(e^{V_D/\eta V_T}\right)$$

$$\Rightarrow I_S = I_D \cdot e^{-\frac{V_D}{\eta V_T}}$$

$$= (1 \times 10^{-3}) \cdot e^{-\frac{0.7}{(1) \cdot 25 \times 10^{-3}}}$$

$\eta = 1$

$V_T = 25$ mV

$$= 10^{-3} \cdot e^{-\frac{700}{25}}$$

$$I_S = 6.9 \times 10^{-16} \text{ Amp}$$

for $\eta = 2$

$$I_s = 10^{-3} \cdot e^{-\frac{700}{2\times 25}}$$

$$\boxed{I_s = 8.3 \times 10^{-10} \text{ Amp}}$$

80) A crystal diode having an internal resistance $r_f = 10\Omega$ is used for center tapped full wave rectification. If the applied voltage is $V = 50 \sin(\pi t)$ and load resistance is $R_L = 1k\Omega$.

(a) Find efficiency

(b) Ripple factor.

(c) Draw O/P current / voltage waveform.

Ans :-

$$I_m = \frac{V_m}{r_f + R_L} = \frac{50}{10 + 1000} = 0.0495 \text{ Amp.}$$

$$I_{dc} = \frac{2I_m}{\pi} = \frac{2 \times 0.0495}{\pi} = 0.0315 \text{ Amp.}$$

$$V_{dc} = I_{dc} \times R_L = 0.0315 \times 1000 = 31.5 \text{ Volt.}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{0.0495}{\sqrt{2}} = 0.035 \text{ Amp.}$$

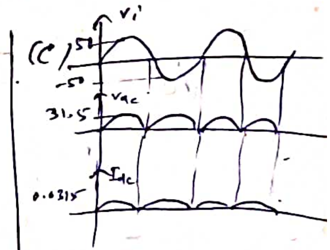
(a) efficiency $(\eta) = 0.812 \times \frac{R_L}{R_f + R_L}$

$$= 0.812 \times \frac{1000}{10 + 1000}$$

$$= 0.8039$$

$$\eta = 80.39\ \%$$

(c)



(b) Ripple factor $= \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{0.035}{0.0315}\right)^2 - 1}$

$$= 0.4842$$

More Problems

1) BPUT-2013

A silicon diode having 20Ω internal resistance is used as half wave rectifier. If the applied input voltage is 50 sin 100πt and load resistance 800Ω, then find

(a) I_m, I_{dc}, I_{rms}

(b) output freq and ripple factor

(c) AC i/p and o/p power and efficiency.

Ans :- Given

Internal resistance, $r_f = 20\Omega$.

$V_i = 50 \sin 100\pi t$.

$R_L = 800\Omega$.

(a) $I_m = \frac{V_m}{r_f + R_L} = \frac{50}{20+800} = \frac{50}{820} = 0.06$ Amp.

$I_{dc} = \frac{I_m}{\pi} = \frac{0.06}{\pi} = 0.019$ Amp.

~~$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{0.06}{\sqrt{2}} =$~~

$I_{rms} = \frac{I_m}{2} = \frac{0.06}{2} = 0.03$ Amp.

(b) O/P freq for half wave

= (i/p freq (supply))

$$\omega = 100\pi$$

$$\Rightarrow 2\pi f_{in} = 100\pi$$

$$\Rightarrow f_{in} = 50\ Hz$$

$$\Rightarrow f_{out} = f_{in} = 50\ Hz$$

Ripple factor (r)

$$r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$$= \sqrt{\left(\frac{0.03}{0.019}\right)^2 - 1}$$

$$r = 1.22$$

(c) A/C i/p power $= I_{rms}^2 (r_f + R_L)$

$$= (0.03)^2 (20 + 800)$$

$$P_{in} = 0.738 \text{ watt.}$$

d.c o/p power, $P_{out} = I_{dc}^2 R_L$

$$= (0.019)^2 \times 800$$

$$P_{out} = 0.2888 \text{ watt.}$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{0.2888}{0.738} = 0.3913$$

(efficiency)

$\%\ \eta$ (efficiency) $= 39.13\ \%$.

Note ÷ If we consider Silicon diode,

$$I_m = \frac{V_{max} - V_T}{r_f + R_L}$$

V_T = Cutin voltage of 'Si' diode. or Threshold voltage for 'Si' = 0.7 Volt

$$\Rightarrow (I_m)_{Si} = \frac{50 - 0.7}{20 + 800} = 0.0601 \text{ Amp.}$$

Ideal diode,

$$(I_m)_{Ideal} = \frac{V_{max}}{r_f + R_L} = \frac{50}{820} = 0.0609 \text{ Amp}$$

$$(I_m)_{Si} \simeq (I_m)_{Ideal} \simeq 0.06 \text{ Amp.}$$

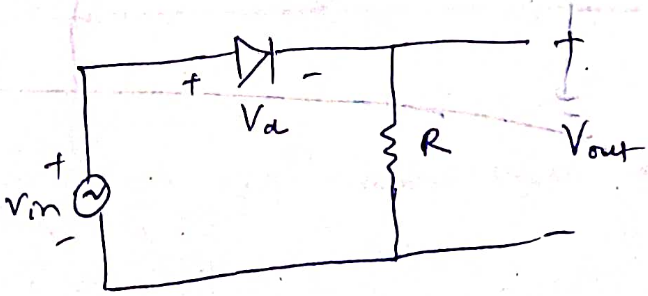
→ For accurate calculation take

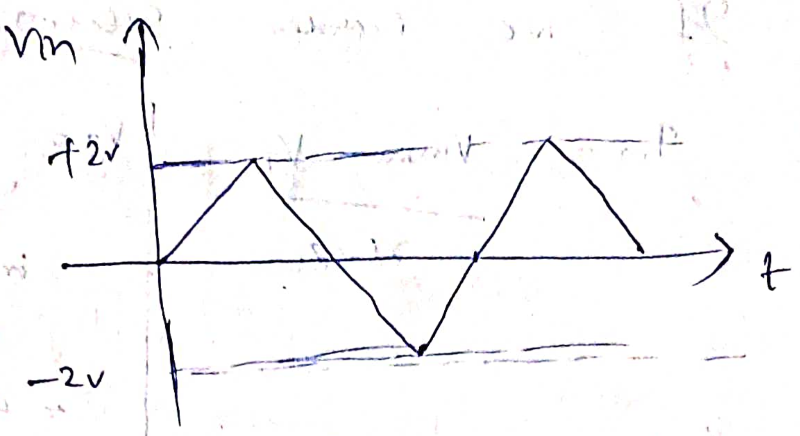
$$(I_m)_{Si} = 0.0601 \text{ Amp.}$$

→ Rest procedure are same as mentioned.

2) BPUT - 2012

Consider the half-wave rectifier with If V_{in} is a triangle wave peak voltage of 2V and diode has $V_d = 0.5V$. Sketch the V_{out}?





Ans :- For +ve half cycle. (less than 0.5 v) i/p

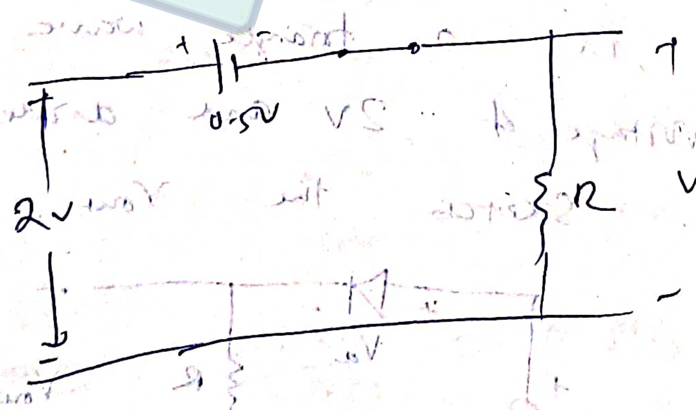
For i/p voltage less than 0.5 V, (cutin)

No current flows, diode reverse biased

(open circuit), o/p = 0V.

→ When i/p voltage exceeds 0.5V, (0.5 0.5)

diode is forward biased, (short circuited)



Applying KVL

$$2 - 0.5 - V_0 = 0$$

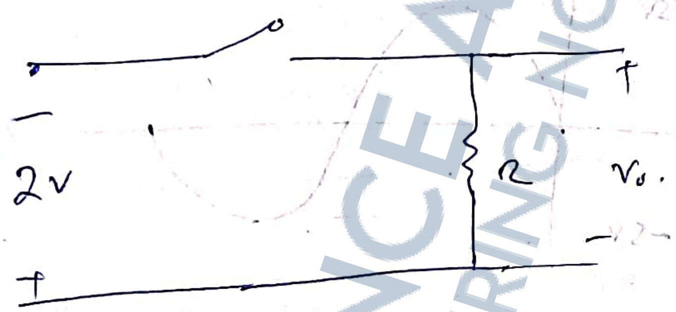
$$\Rightarrow \boxed{V_0 = 1.5\ V}$$

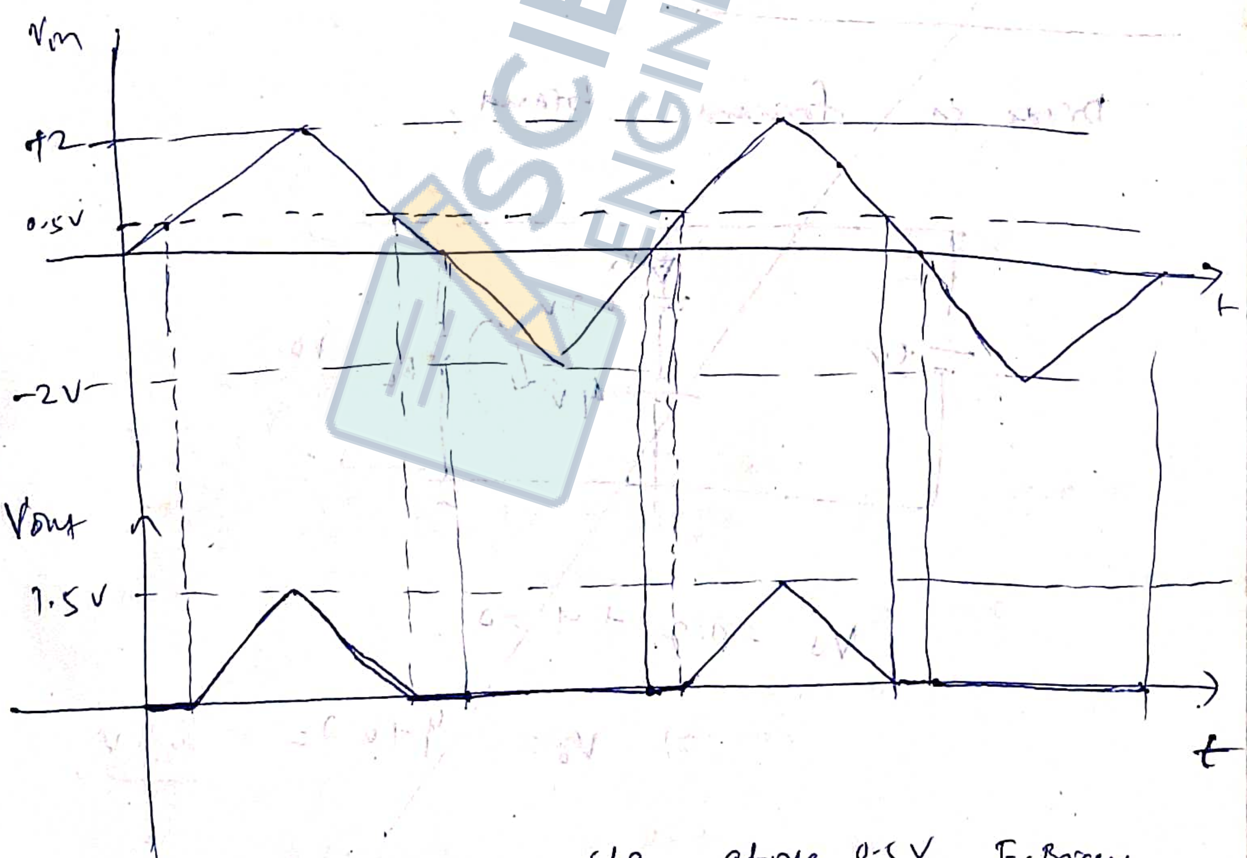
→ For i/p 0.5 V to 0V, diode R.B. O/P = 0.

For −ve half cycle.

Diode is reverse biased open circuit.

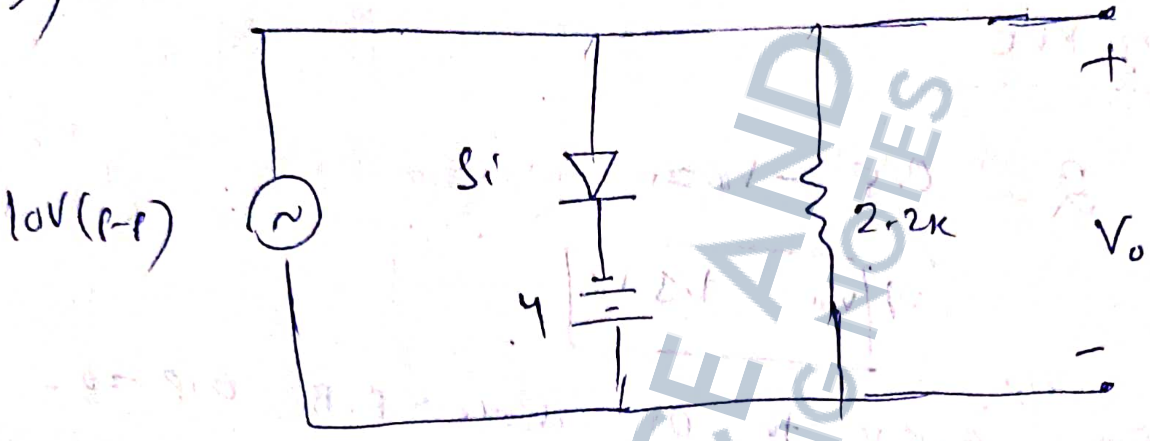
the O/P = 0 volt.





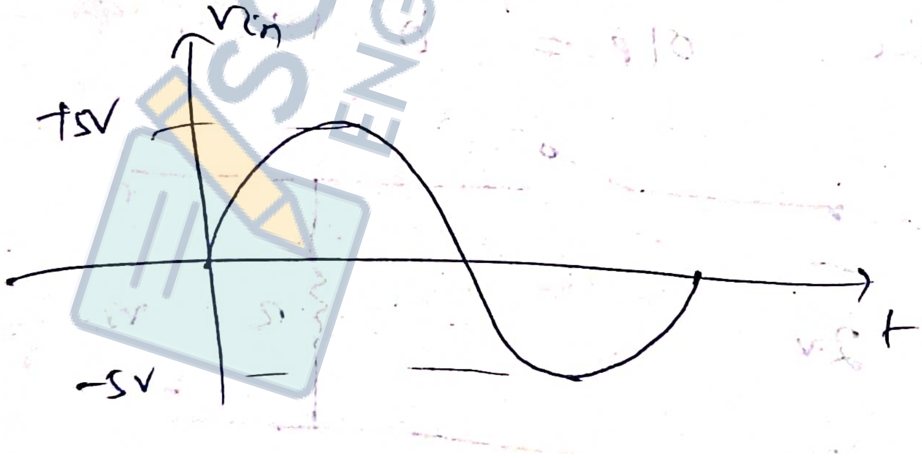
So Portion of i/p above 0.5 V F. Biased.
" " below " R. biased.

37)

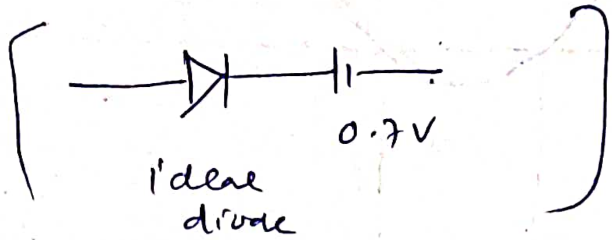


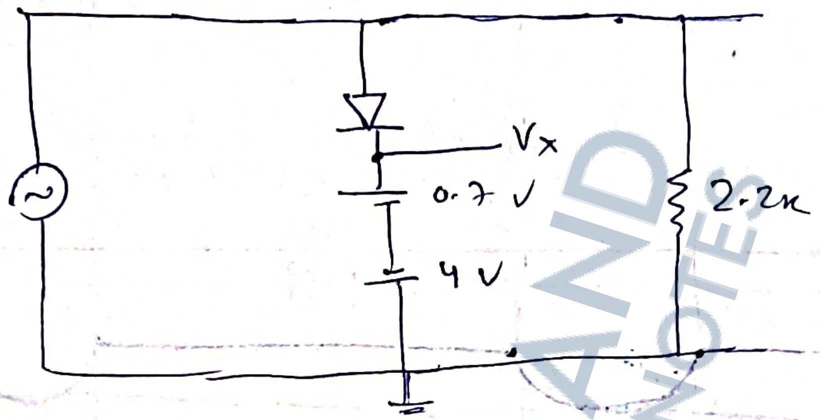
Find Vo = ?

Ans :- i/p voltage



→ A Si diode can be redrawn as





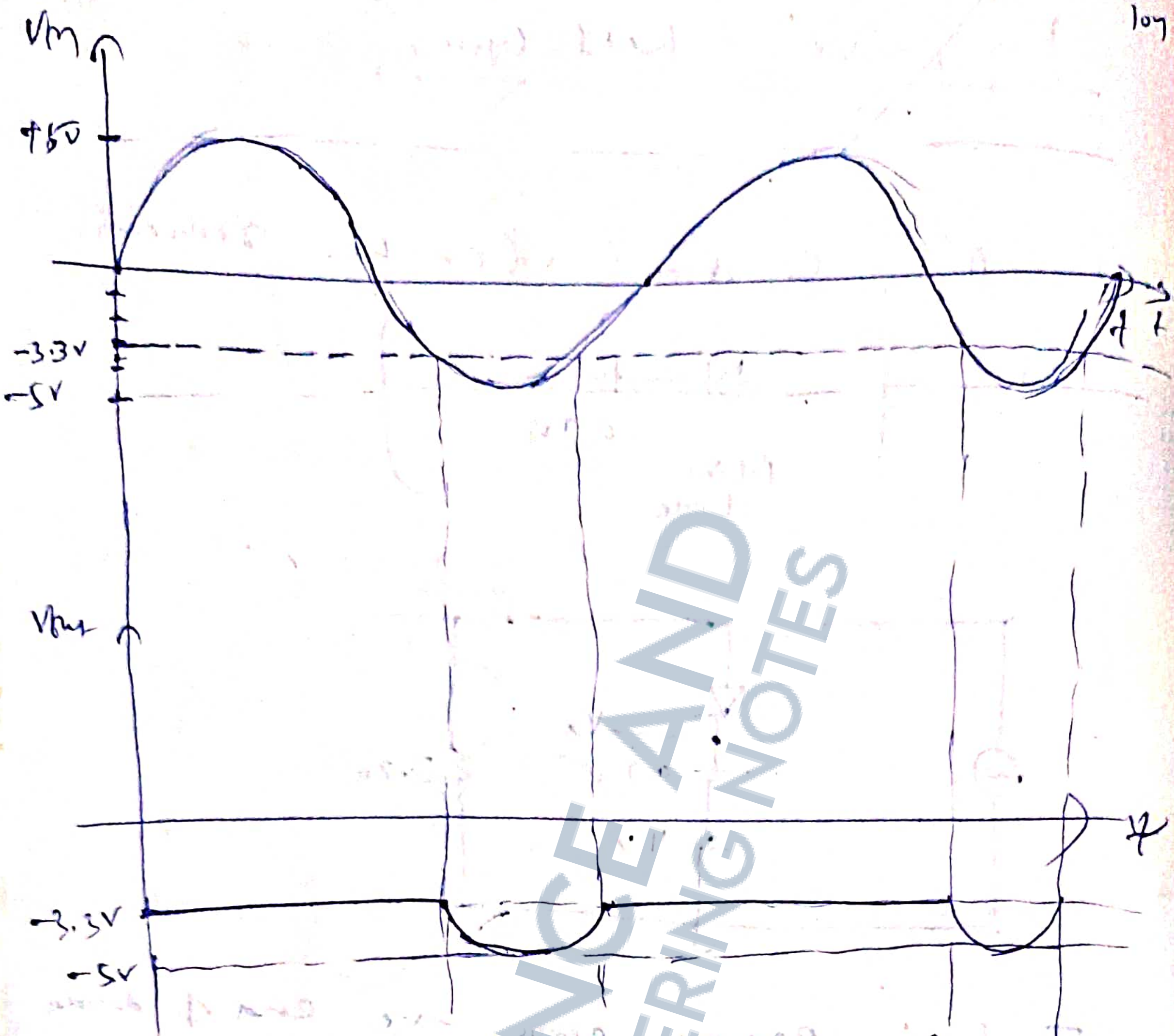
To find potential across -ve end of diode (V_x), Applying KVL,

$$V_x - 0.7 + 4 = 0$$

$$\Rightarrow V_x = -4 + 0.7 = \underline{-3.3V}.$$

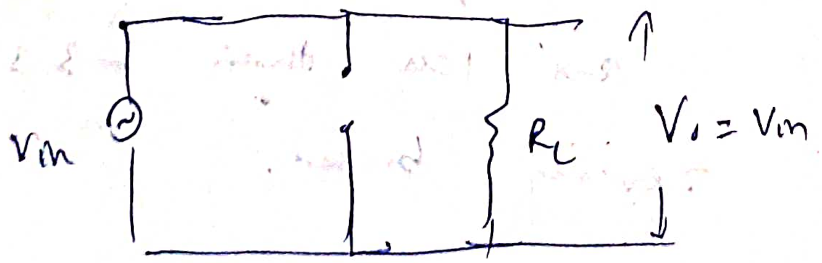
So for all the i/p voltages i.e more than -3.3 V diode is forward biased.

and less than -3.3 V its reverse biased.

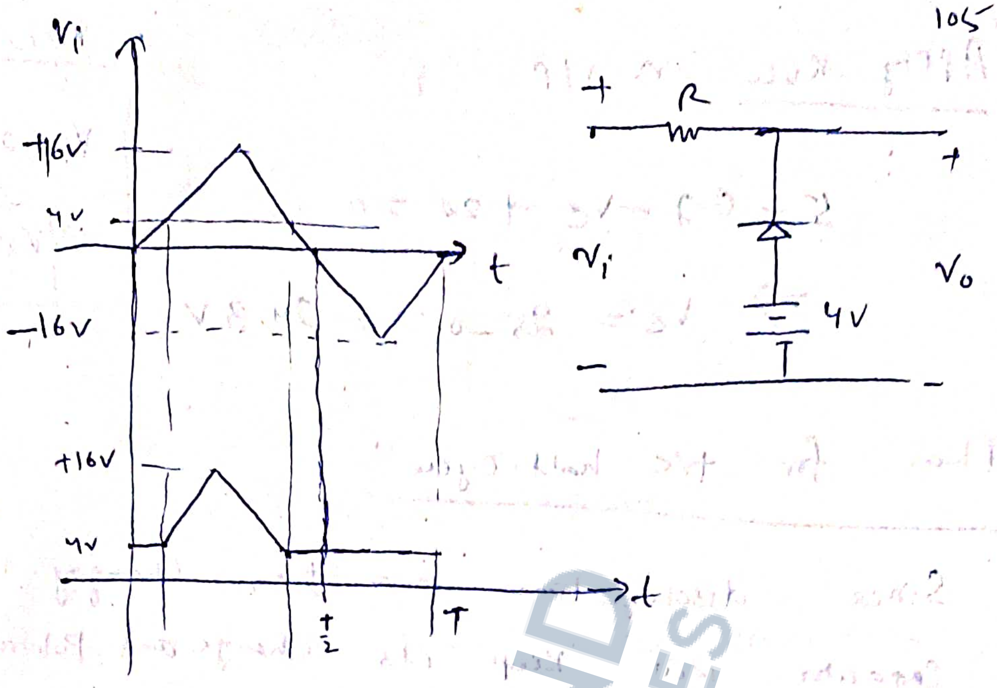


For the i/p voltage above -3.3v (i.e 0 to -3.299)

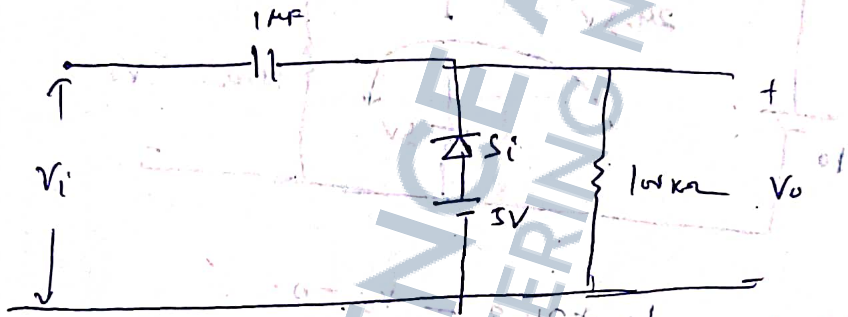
o/p below -3.3v i.e (-3.3 to -5v)



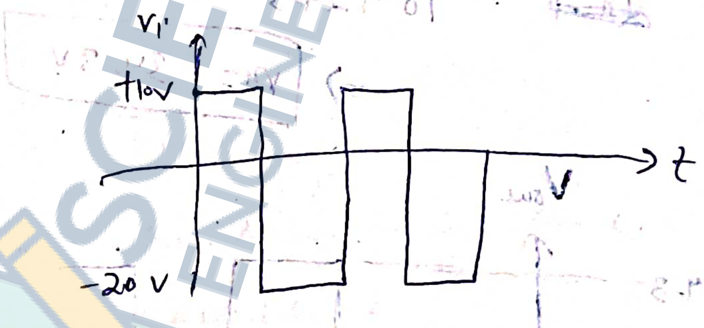
4)



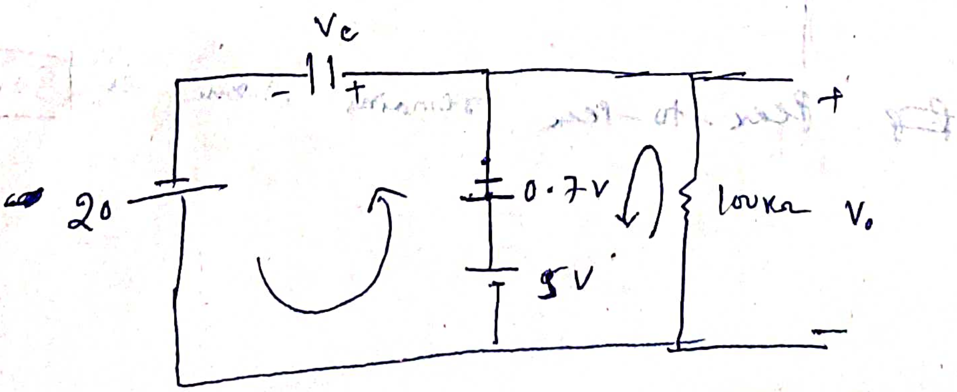
5) Clamper ckt. Problem



v_i =



Ans.: First start the analysis for the cycle, when the diode is Forward biased. i.e -ve half cycle.



Apply KVL in i/p

$$5 - 0.7 - V_C + 20 = 0$$

$$\Rightarrow V_C = 25 - 0.7 = 24.3\,V$$

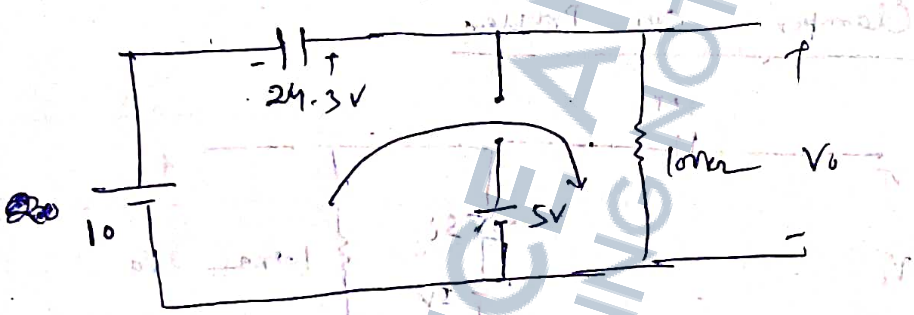
KVL in o/p

$$V_0 + 0.7 - 5 = 0$$

$$\Rightarrow \boxed{V_0 = 4.3V}$$

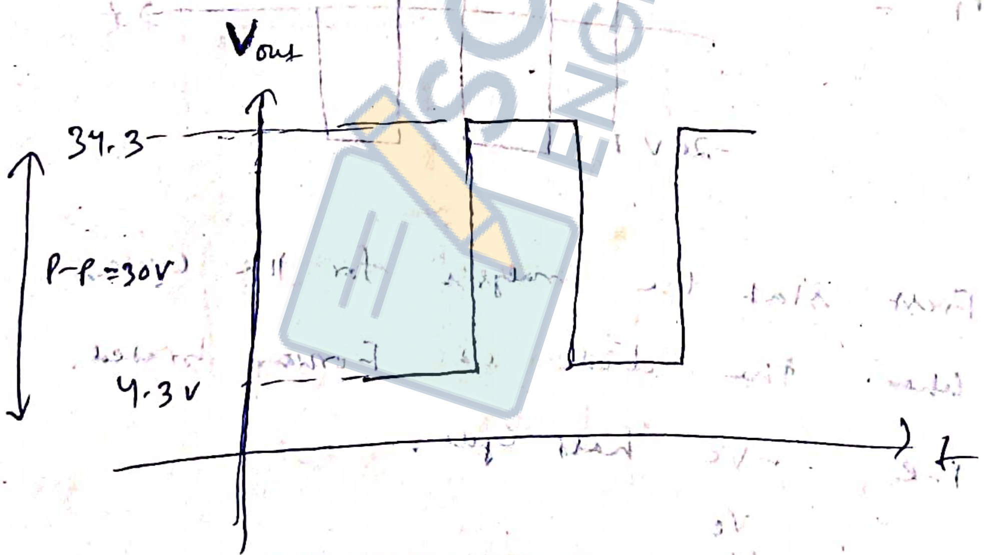
Then for -ve half cycle

Since discharge time more than charging time, capacitor will keep its charge and polarity.



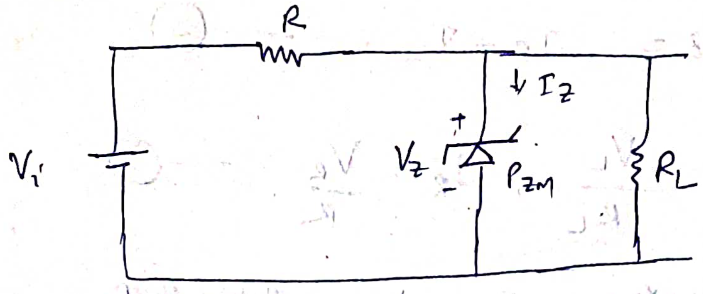
$$10 + 24.3 - V_0 = 0$$

$$\Rightarrow \boxed{V_0 = 34.3V}$$



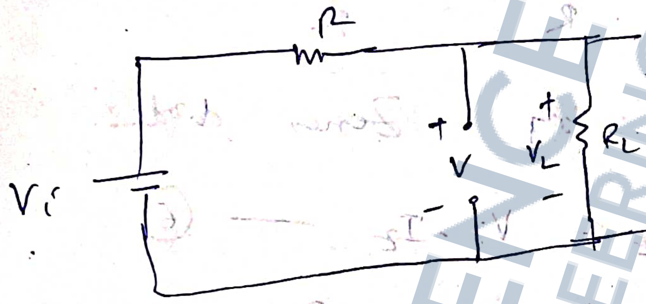
Peak-to-peak remains same as $\boxed{30V}$.

Zener diode



Basic Zener regulator

1) Determining the state of the Zener diode by removing it from the n/w and calculating the voltage across the resulting open ckt.



$$V = V_L = \frac{V_i}{R+R_L} \cdot R_L$$

If $V < V_Z$, the diode is off, open ckt equivalence is substituted.

If $V \geq V_Z$, the Zener diode is on, it is replaced by a battery source having voltage ~~equal~~ equal to breakdown voltage of Zener diode.

2)

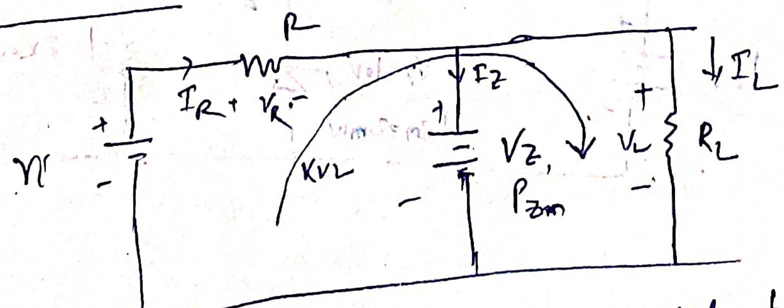


fig:- Zener equivalent for "on" situation.

$$I_R = I_Z + I_L \quad \text{--- (1)}$$

$$I_Z = I_R - I_L \quad \text{--- (2)}$$

$$I_L = \frac{V_L}{R_L}, \quad I_R = \frac{V_R}{R} \quad \text{--- (3)}$$

Applying KVL in the outer loop,

$$V_i - V_R - V_L = 0$$

$$\Rightarrow V_R = V_i - V_L \quad \text{--- (4)}$$

$$\therefore I_R = \frac{V_R}{R} = \frac{V_i - V_L}{R} \quad \text{--- (5)}$$

• Power dissipated by Zener diode

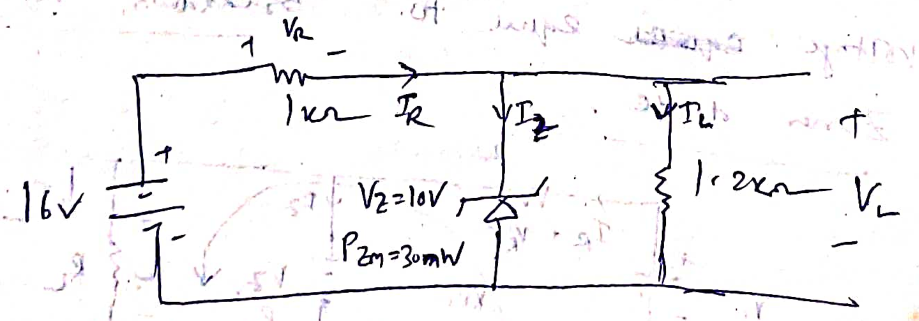
$$P_Z = V_Z \cdot I_Z \quad \text{--- (6)}$$

which must be less than $\underline{P_{ZM}}$ specified for the device.

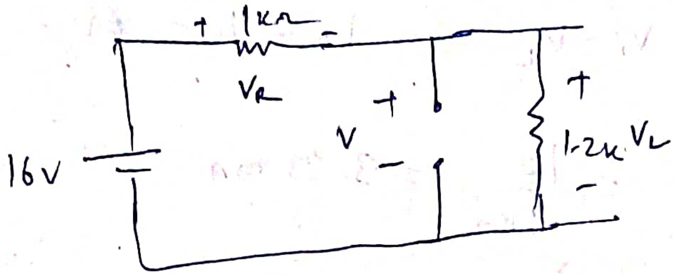
Ex:-6) For the Zener diode n/w, determine

(a) V_L, V_R, I_Z, P_Z.

(b) Repeat (a) with $R_L = 3\,k\Omega$



Ans :- (a) <u>Determining the State of Zener diode</u>



$$V = \frac{16}{(1+1.2)\,k\Omega} \times 1.2\,k\Omega = 8.73V.$$

Since $V < V_Z$, i.e. $8.73V < 10V$, the diode is off state.

So $V_L = V = 8.73V$

$V_R = V_i - V_L = 16 - 8.73 = 7.27V.$

$I_Z = 0A$

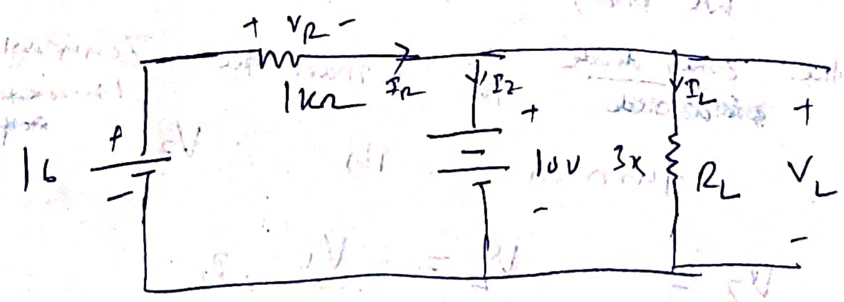
$P_Z = 0$ watt $(\because V_Z \cdot I_Z = 0)$

(b) <u>When $R_L = 3k\Omega$</u>

$$V = \frac{16}{(1+3)\,k\Omega} \times 3\,k\Omega = \frac{16}{4} \times 3 = +12V.$$

Since $V > V_Z$, i.e. $12V > 10V$, diode is on state

Replacing by "on" state model.



$$V_L = V_Z = 10V$$

$$V_R = V_i - V_L = 16 - 10 = 6V.$$

$$I_L = \frac{V_L}{R_L} = \frac{10}{3k\Omega} = 3.33\,mA$$

$$I_R = \frac{V_R}{R} = \frac{6}{1k\Omega} = 6\,mA$$

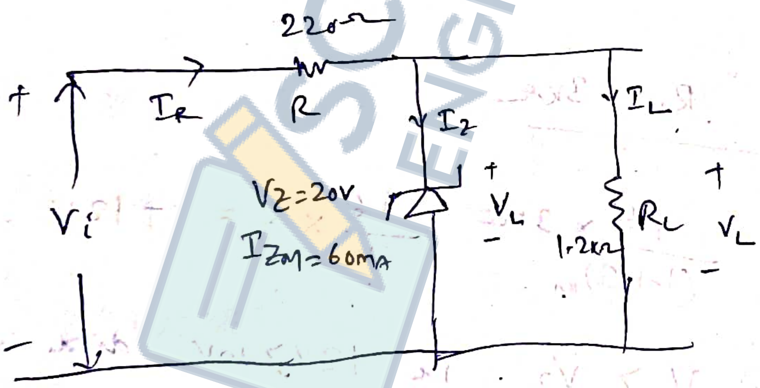
$$I_Z = I_R - I_L = 6 - 3.33 = 2.67\,mA.$$

Power dissipated is

$$P_Z = I_Z \cdot V_Z = 2.67 \times 10^{-3} \times 10V = 26.7\,mW$$

which is less than P_{Zm} i.e. 30 mW.

7) For the n/w, determine the range of values of 'V_i' that will maintain the Zener diode in "on" state.



Ans: We know, the minimum voltage required across the Zener diode to make the Zener diode turn on is V_Z (breakdown voltage)

$$V_Z = V_L = \frac{V_i}{R + R_L} \times R_L$$

So minm input voltage required is,

$$(V_i)_{min} = \frac{V_z \times (R + R_L)}{R_L}$$

$$= \frac{20 \times (220\Omega + 1200\Omega)}{1200}$$

$$= \frac{20 \times 1420}{1200}$$

$$\boxed{(V_i)_{min} = 23.67V}$$

→ Since Zener voltage will act as voltage regulator, V_L will be always 20V.

$$I_L = \frac{V_L}{R_L} = \frac{20}{1.2\,k\Omega} = 16.67\,mA.$$

→ To find the maxm i/p variation

I_L = const = 16.67 mA.

I_Z will maxm vary up to 60mA as specified for the Zener diode.

$$(I_R)_{max} = I_L + I_{ZM}$$

$$= 16.67\,mA + 60\,mA$$

$$(I_R)_{max} = 76.67\,mA$$

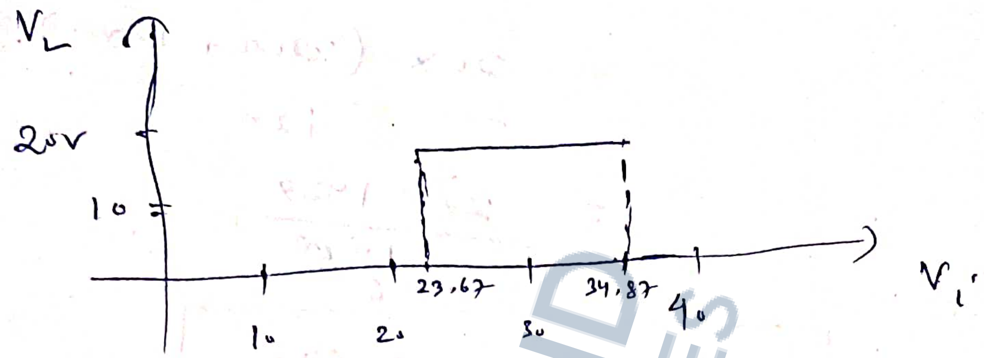
$$(V_i)_{max} = (V_R)_{max} + V_Z$$

$$= I_{max}\,R + V_Z$$

$$= 76.67 \times 10^{-3} \cdot 22 \times 10^{3} + 20$$

$(V_i)_{max} = 16.87V + 20$

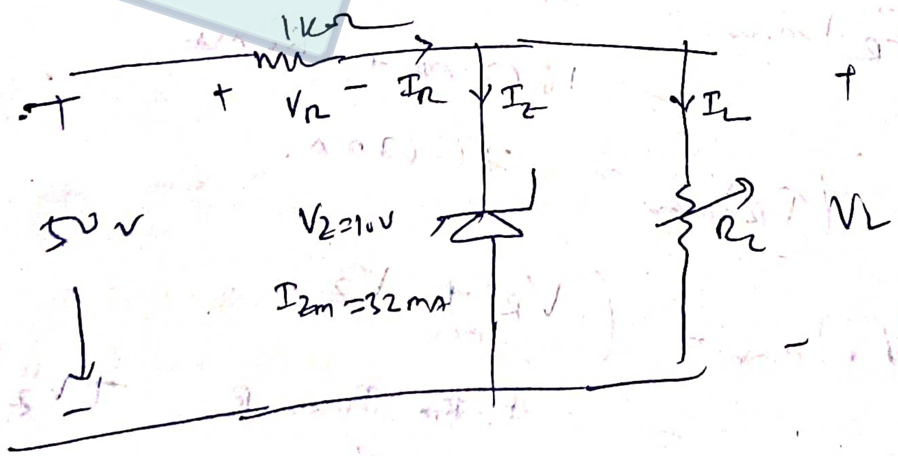
$(V_i')_{max} = 36.87V$



We can see from the plot that, even if the i/p voltage is fluctuating betn 23.67 to 34.87 V, o/p voltage remains Const. as 20 V.

8) (a) Determine the range of R_L & I_L that will result in V_{RL} being maintained at 10V.

(b) Determine the max^m wattage rating of diode.



Ans :- We know to make the Zener turn on, minm voltage required is V_Z.

and $V_Z = V_L = \frac{V_i}{R+R_L} \times R_L$

$\Rightarrow 10 = \frac{50}{1k\Omega + R_L} \times R_L$

$\Rightarrow 10 = \frac{50}{1000 + R_L} \times R_L$

$\Rightarrow 10,000 + 10R_L = 50 R_L$

$\Rightarrow 40 R_L = 10,000$

$\Rightarrow R_L = 250\Omega$

∴ Minm R_L, $(R_L)_{min}$ required is $\boxed{250\Omega}$ to make the diode 'on'.

To find $(R_L)_{max}$, to maintain Zener as voltage stabilizer.

~~We know~~ Applying KVL,

$V_i - V_R - V_L = 0$

$\Rightarrow V_i - IR - 10 = 0$

$\Rightarrow I_R R = V_i - 10$

$\Rightarrow R = \frac{V_i - 10}{I_R}$

$\Rightarrow 1000 = \frac{50-10}{I_R}$ —— (1)

To find $(R_L)_{max}$, (I_L) should be minimum. $(I_L)_{min}$.

→ Since R is const = 1 kΩ

from eqⁿ ①, I_R = const.

$\Rightarrow I_L + I_Z$ = const.

To find $(I_L)_{min}$, (I_Z) has be maxᵐ

$(I_Z)_{max} = 32\,mA$.

~~⇒ $(I_L)_{min}$ = 40~~

from eqⁿ ①

$$1000 = \frac{40}{(I_L)_{min} + (I_Z)_{max}}$$

$\Rightarrow (I_L)_{min} + (I_Z)_{max} = 40\,mA$

$\Rightarrow (I_L)_{min} + 32\,mA = 40\,mA$

$\Rightarrow \boxed{(I_L)_{min} = 8\,mA}$

$\therefore (R_L)_{max} = \frac{V_L}{(I_L)_{min}} = \frac{10}{8\,mA} = 1.25\,k\Omega$.

$\boxed{(R_L)_{max} = 1.25\,k\Omega}$

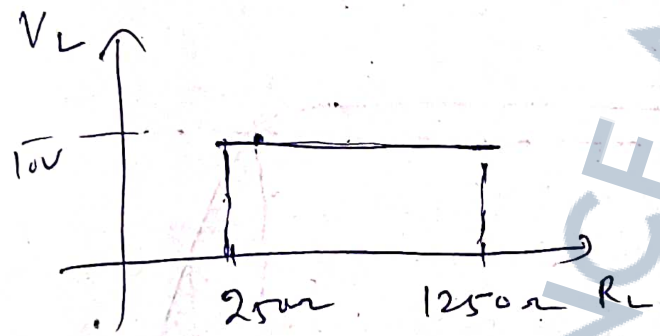
$(R_L)_{min} = 250\,\Omega$, so $(I_L)_{max} = \frac{10\,V}{250\,\Omega} = 40\,mA$.

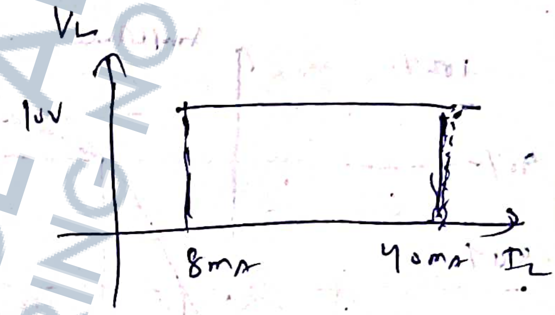
So $(R_L) \rightarrow$ varying from $250\,\Omega$ to $1.25\,k\Omega$,

The O/P remains const $= 10\,V$.

i.e (I_L) varying from $\rightarrow$ $40\,mA$ to $8\,mA$

O/P remains const $= 10\,V$.





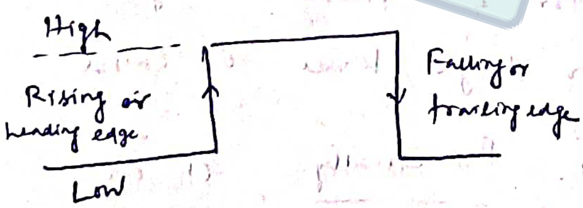
(b) Max^m wattage rating of diode.

$= V_Z \times I_{ZM}$

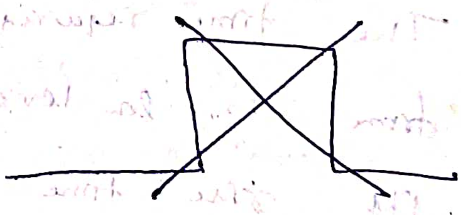
$= 10 \times 32\,mA$

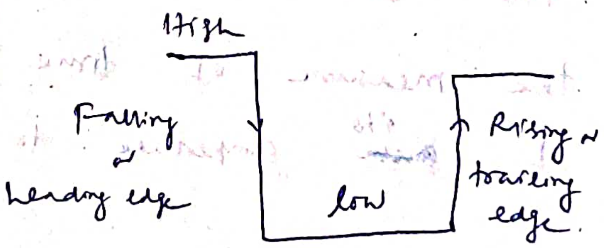
$P_{ZM} = 320\,mWatt$.

Digital Waveform :-



(a) +ve going pulse

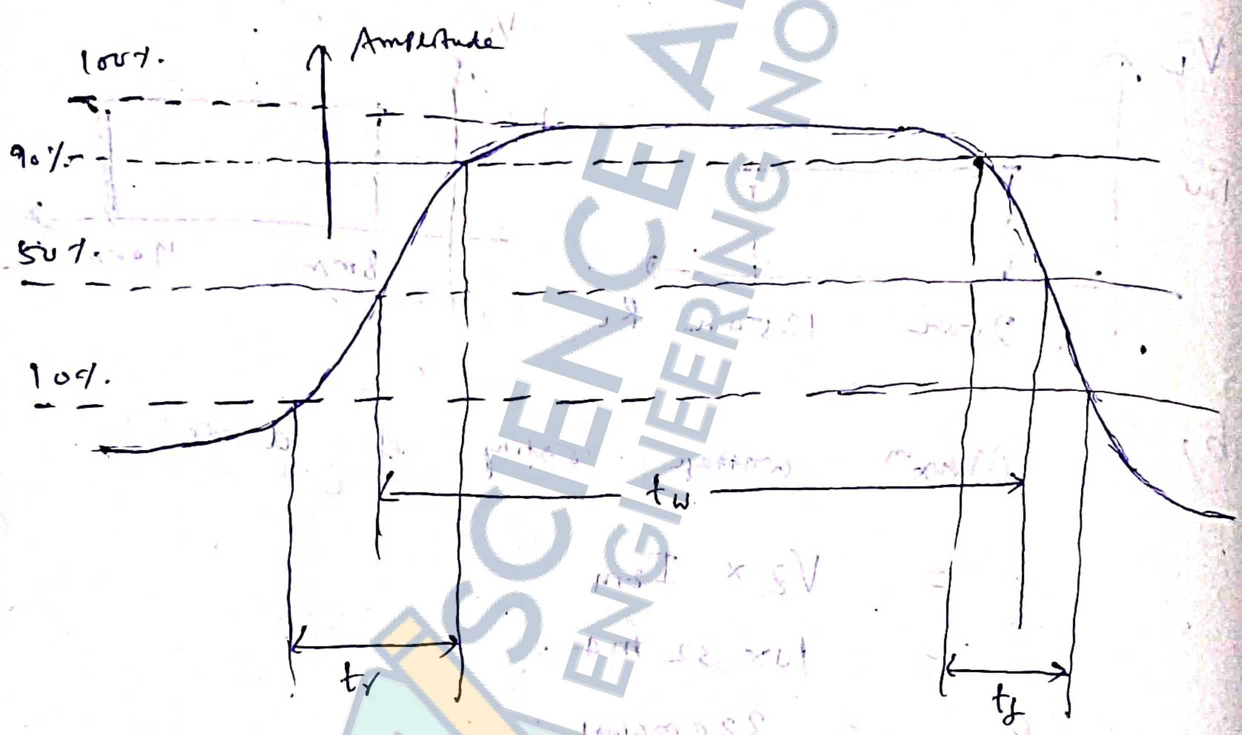




(b) −ve going pulse

→ A +ve going pulse is generated when the voltage (current) goes from its normally low level to its high and then backs to low level.

→ A -ve going pulse is generated when the voltage goes from its normally High level to its low level and backs to high level.



→ t_r (rise time)

The time required for a pulse to go from its low level to high level is called its rise time (t_r). Practically, it is the measure of time taken by the pulse to rise from 10% of its amplitude to 90% of its amplitude.

t_f (fall time)

The time required for a pulse's transition from high level to low level is called the fall time (t_f)

Practically It is the measure of the time taken by pulse to go from 90% to 10% of its amplitude.

Pulse width (t_w)

It is the time interval ~~period~~ betn 50% of leading edge to 50% of trailing edge amplitude.

Duty cycle

It is the ratio of pulse width to its time period.

$$\text{Duty cycle} = \frac{t_w}{T} = \frac{\text{Pulse width}}{\text{Time Period}}$$

$$\left(f = \frac{1}{T} \quad \text{i.e frequency} = \frac{1}{\text{Time period}} \right)$$

or, Pulse width:-

It is ~~the~~ a measure of the duration of the pulse. And it is often defined as the time interval between 50% of point on the rising and falling edge.

1) P-N Junction diode made up of which material (Si, Ge, $GaAs$) will have highest thermal stability and why?

A:- P-N J^n diode made up of 'Si' material will have highest thermal stability, because silicon diodes operated in Avalanche breakdown are available with maintaining voltages from several volts to several hundred volts with power rating up to 50 watts. They can operate on high temperature.

2) A signal is represented by

$$y = 5 \sin (628t + 30)$$

Find freq, amplitude and initial phase of signal.

Ans:- Standard eqn of signal,

$$y = A \sin (\omega t + \phi)$$

$$\boxed{A = \text{Amplitude} = 5\,V}$$

$\omega = 628 \Rightarrow 2\pi f = 628$

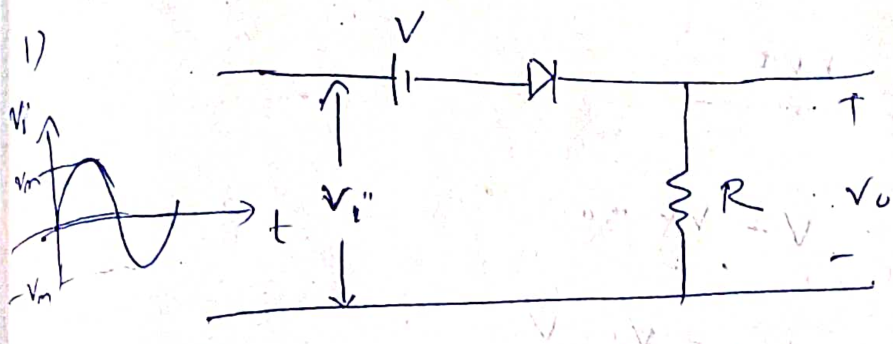
$\Rightarrow 2 \times 3.14 \times f = 628$

$$\Rightarrow \boxed{f = 100\ Hz}$$

Phase, $\phi = 30°$.

More problems

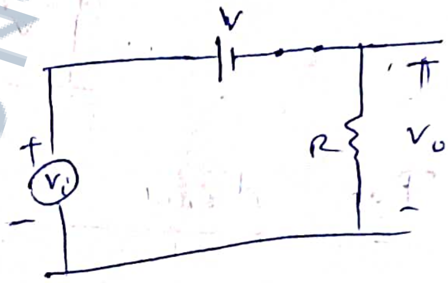
1)



Answer :- Steps

1) If diode is F.B what is the o/p.

$$V_i - V - V_o = 0$$



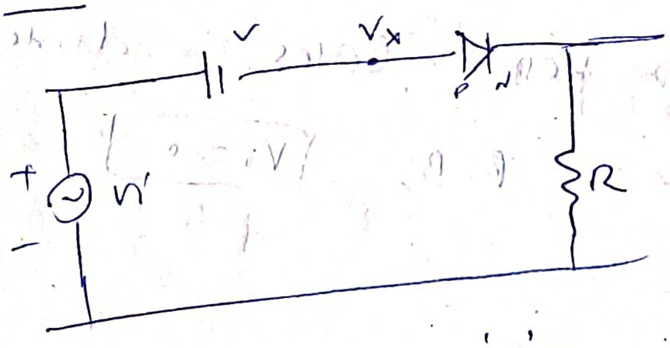
$$\Rightarrow \boxed{V_o = V_i - V}$$

2) If diode is R.B. , diode is open ckted, o/p is Zero.

$$\boxed{V_o = 0}$$

3) What is the condition for diode to be F.B

→



For the PN Jn, 'N' is connected to ground. So Potential at P (V_x)

$V_x > 0$.

Applying KVL

$$V_i - V - V_x = 0$$

$$\Rightarrow V_x = V_i - V$$

$\Rightarrow$ $V_x > 0$.

$$V_i - V > 0$$

$$\boxed{V_i > V}$$

To draw the wave form.

1) First draw the i/p wave form.

2) Draw a line at $V_i = V$.

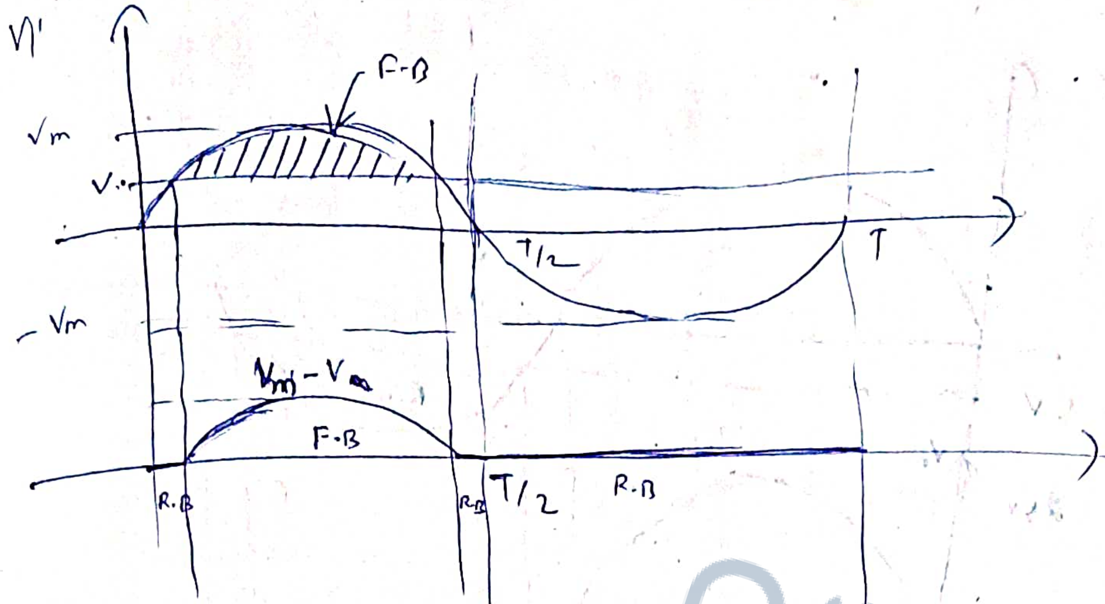
3) For $V_i > V$, Divide F.B

o/p is $\boxed{V_i - V}$ [See the step 1 as last page]

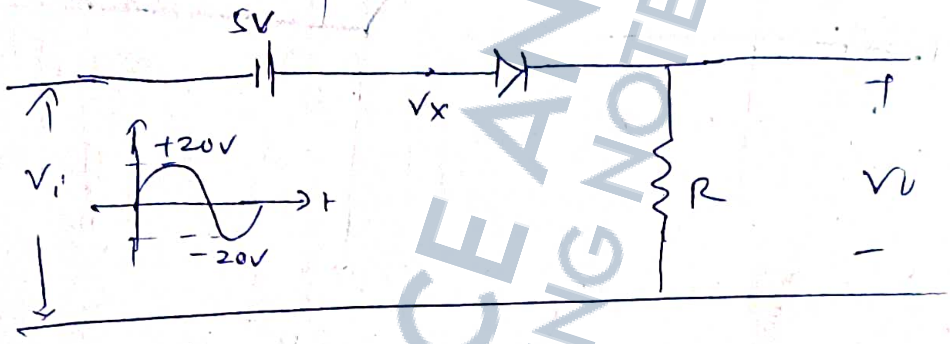
→ Max^m Amplitude $V_m - V$

4) For Rest Cases divide in R.B.

For R.B, $\boxed{V_0 = 0}$ (see the 2nd after last page)



2)



Step 1:- If diode is F.B.

$$V_i + 5 - V_o = 0 \Rightarrow \boxed{V_o = V_i + 5}$$

2) If diode is R.B., O/P = 0

3) Condition for diode is F.B

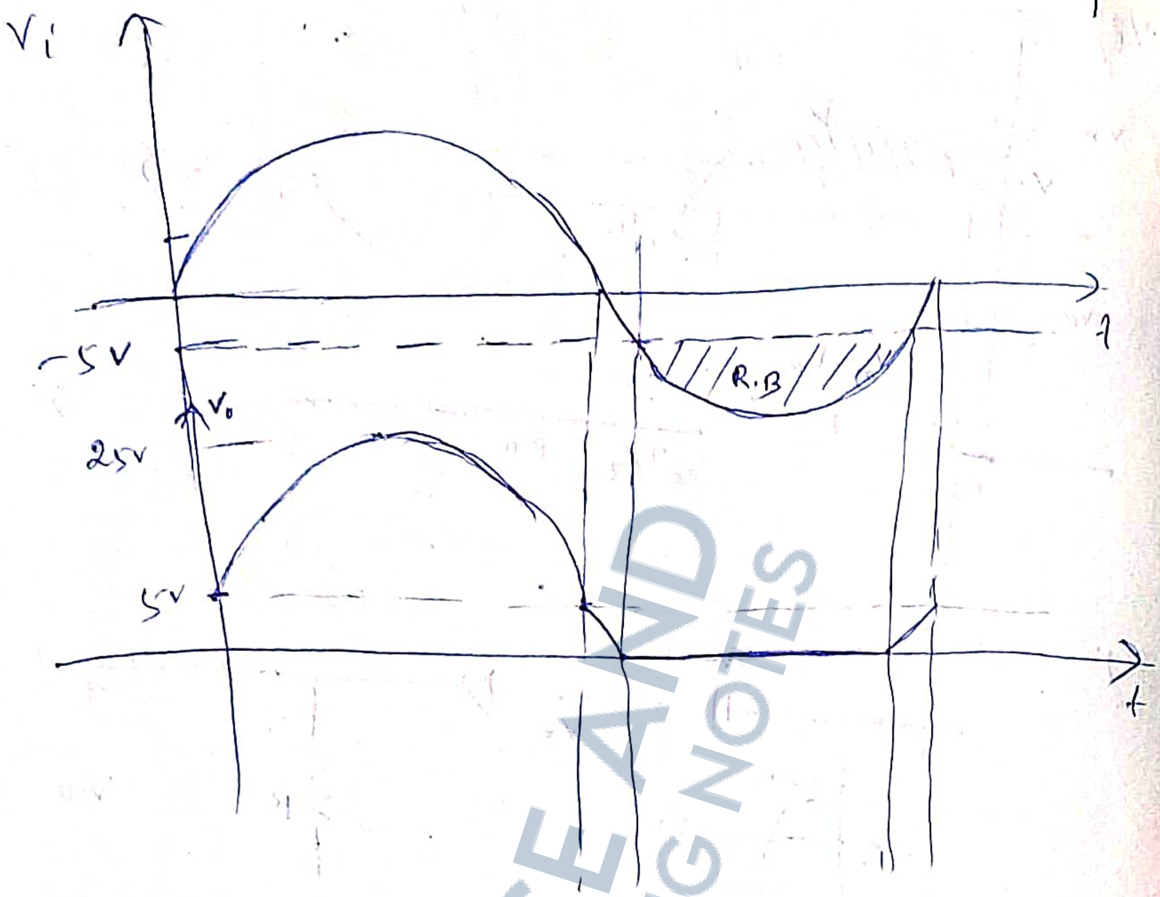
$$V_i + 5 - V_x = 0.$$

$$\Rightarrow V_x = V_i + 5$$

$$V_x > 0.$$

$$V_i + 5 > 0$$

$$\boxed{V_i > -5V}$$



For $V_i < -5V$, diode is R.B

o/p = zero

Rest cases o/p is, $V_i + 5$.

$V_i = 0$, $V_0 = 5$

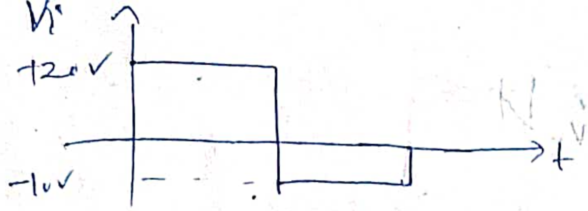
$V_i = 20$, $V_0 = 25$

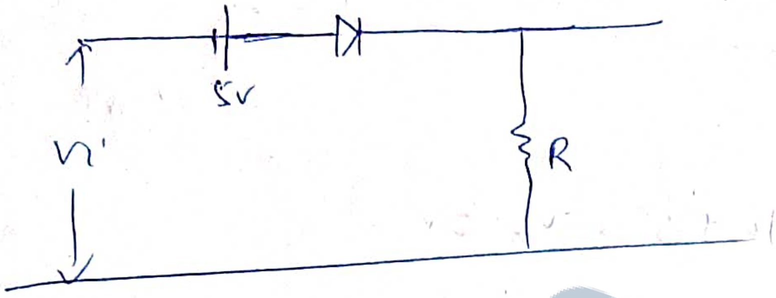
$V_i = -5$, $V_0 = 0$

$V_i = -4$, $V_0 = 1$

$V_i = 0$, $V_0 = 5$

3)





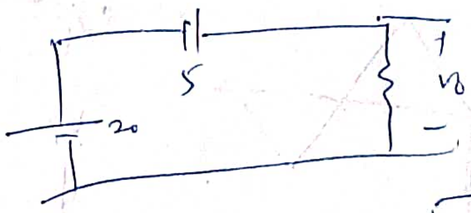
→ A:- Analysis of clipper with square wave i/p is easier because only 2 levels to be considered.

Step 1: When diode is F.B, O/P

20 + 5 − Vo = 0 ⇒ $\boxed{V_0 = 25V}$

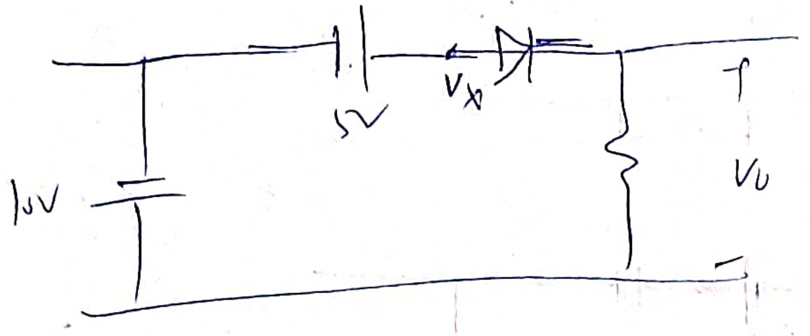
Step 2:- When diode is R.B, $\boxed{V_0 = 0}$

For +ve half cycle



+20 + 5 − Vo = 0 ⇒ $\boxed{V_0 = 25V}$

For −ve half cycle



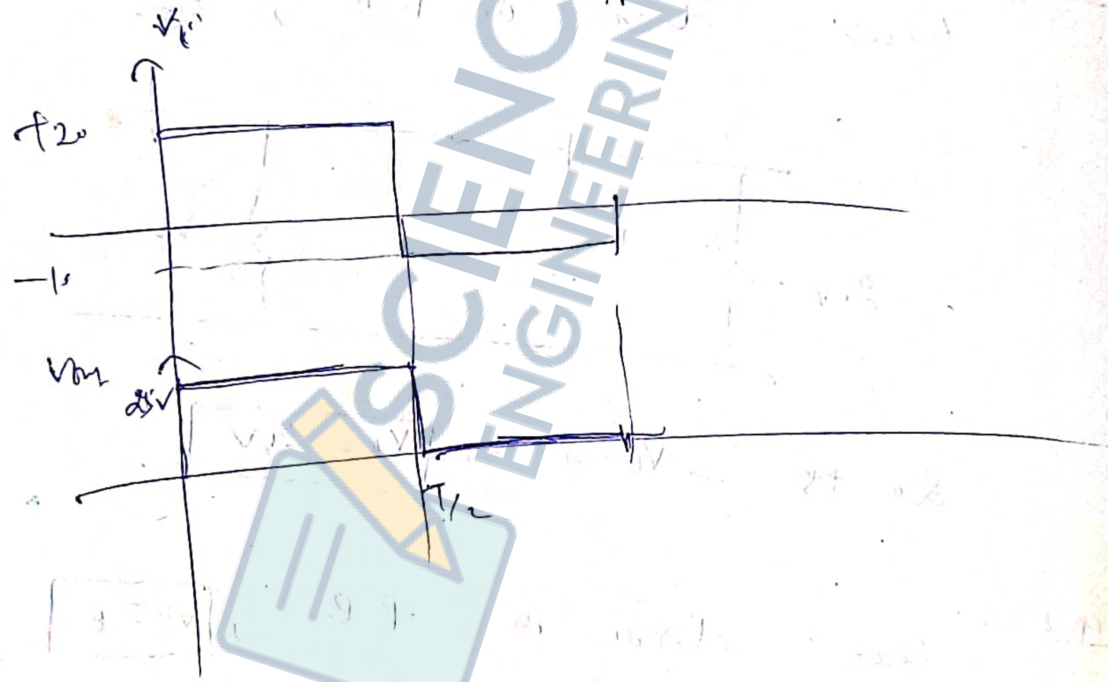
$-10 + 5 - V_x = 0$

$\Rightarrow V_x = 10 - 15 = -5V$

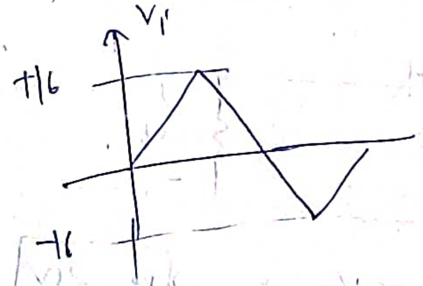
~~Since~~ ∴ diode is R.B.

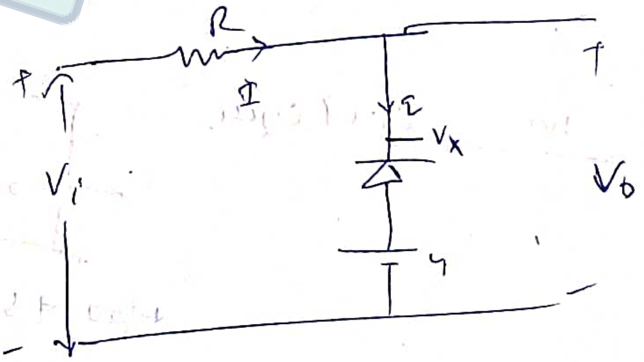
for -ve half cycle

O/P = 0.



4)





7

Ans :- (i) When diode is F.B.

~~$V_0 = V_i$~~ $V_0 = 4V$.

(ii) When diode is R.B, open circuited.

$I = 0$.

$$V_0 = V_i$$

(iii) Consider, when diode is F.B.

$V_i - IR - V_X = 0$.

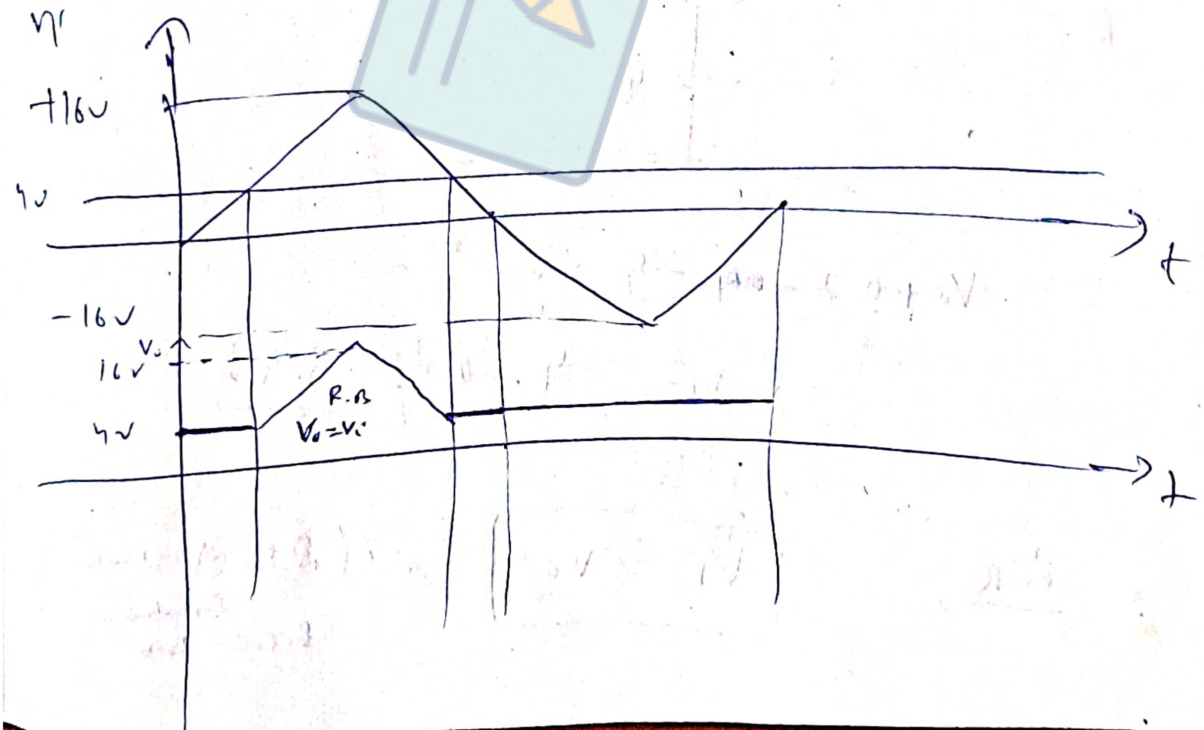
↳ Current has not started. diode is off state.

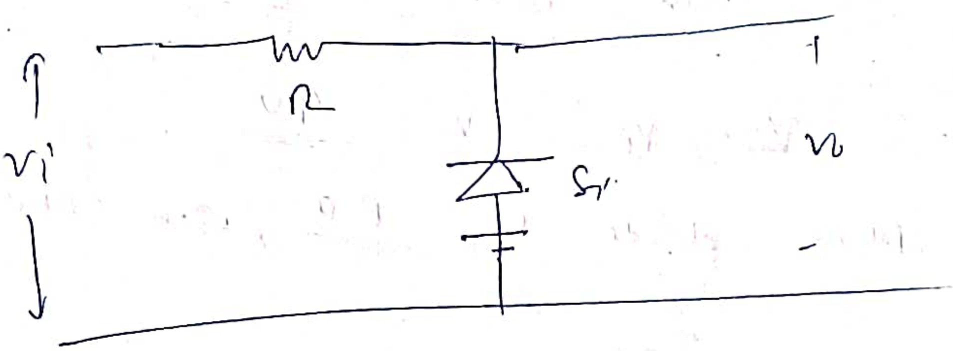
$$V_X = V_i$$

~~V_X~~ To make the diode F.B.

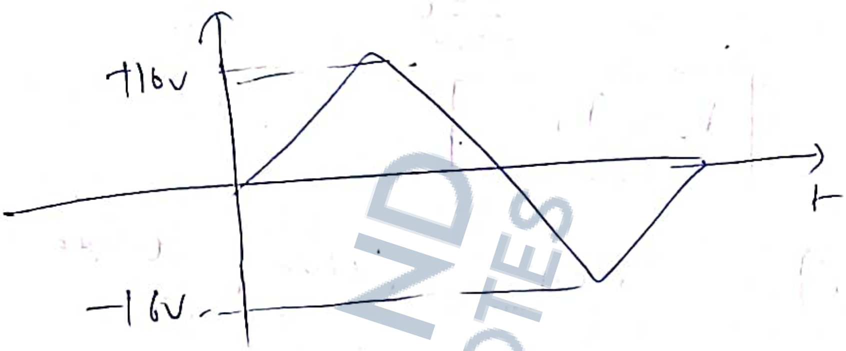
$V_X < 4V$.

$$V_i < 4V.$$ and at F.B O/P = 4V.

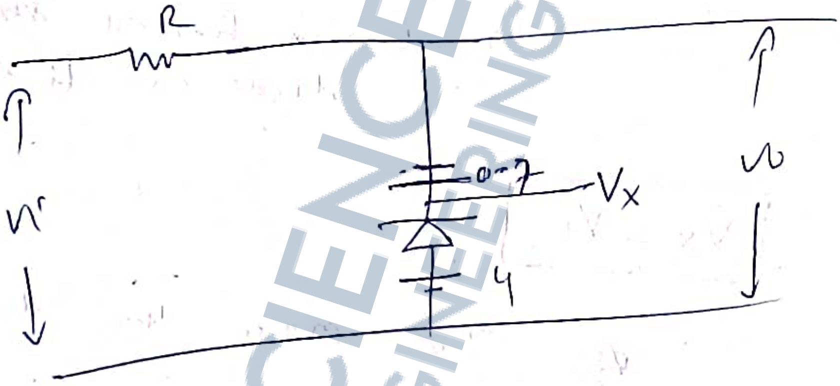




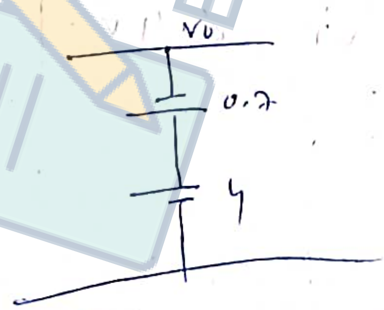
V_i =



Ans:



1) When diode F.B.



$$V_o + 0.7 - 4 = 0$$

$$\Rightarrow V_o = 4 - 0.7 = 3.3V$$

2) R.B, $V_i = V_o$ (As discussed ~~earlier~~ previous prob.)

37 Consider for diode F.B. 9

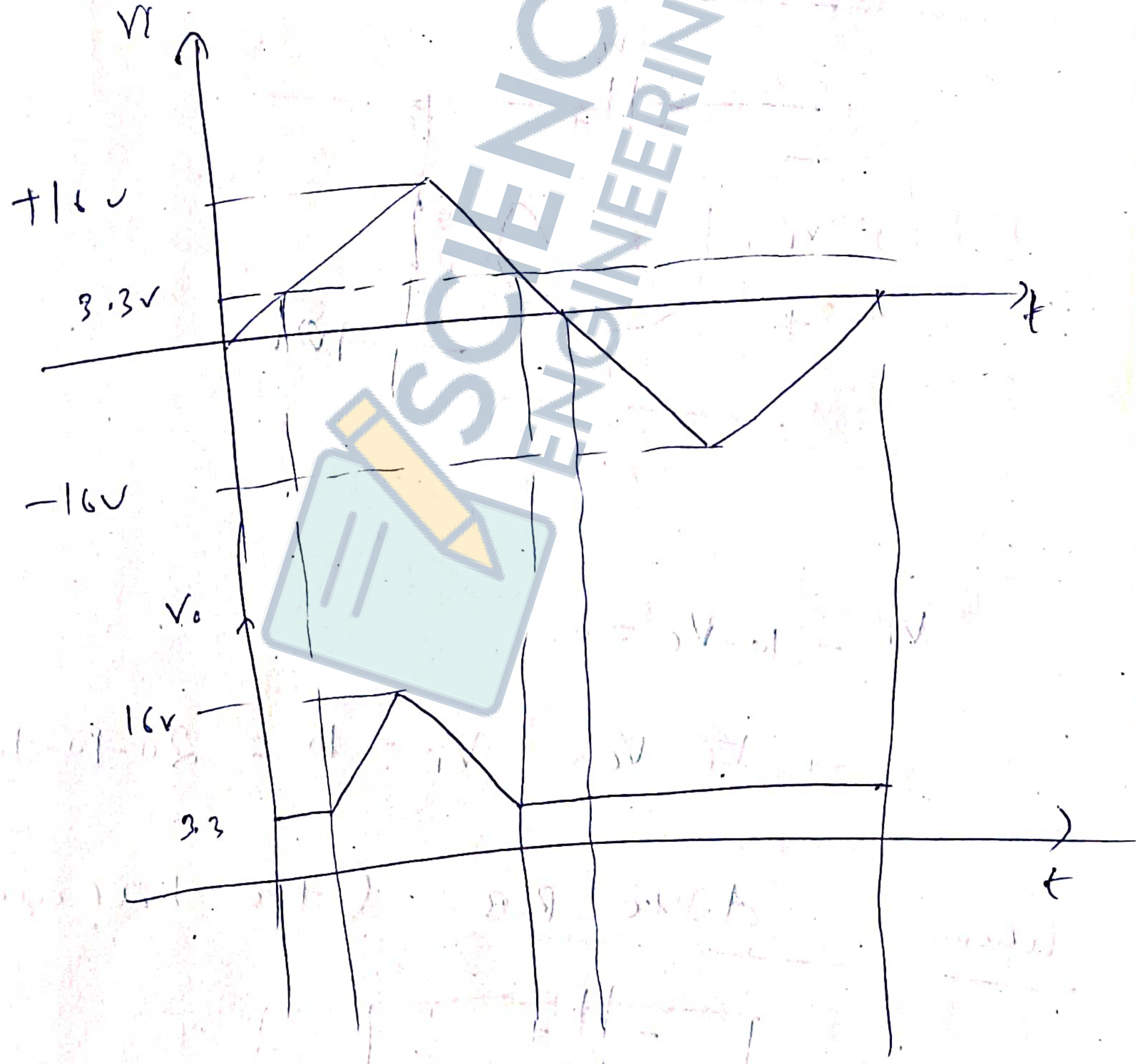
$V_i - 0.R + 0.7 - V_x \Rightarrow$

$\Rightarrow V_x = V_i + 0.7$

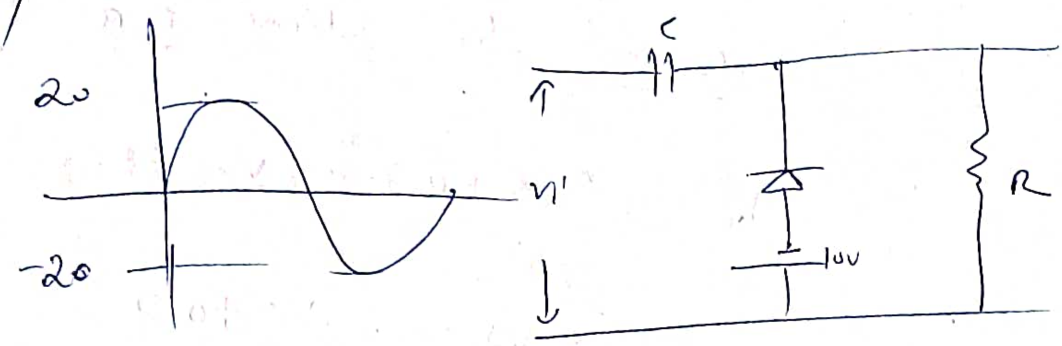
$V_x < 4$

$V_i + 0.7 < 4$

$\Rightarrow \boxed{V_i < 3.3}$



6)



~~-ve half cycle~~

When diode F-B (-ve half cycle)

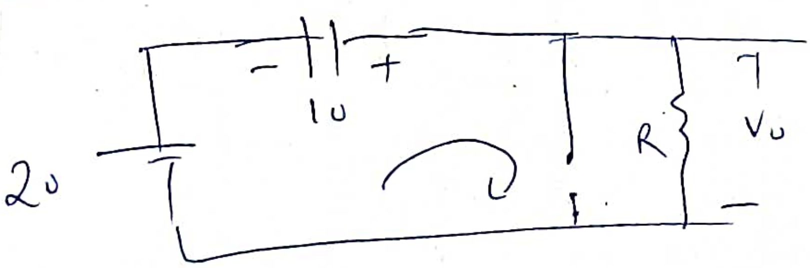
O/P is (-10V) (sinusoidal)

Capacitor is Charged

$V_1' - 10 - V_C = 0$

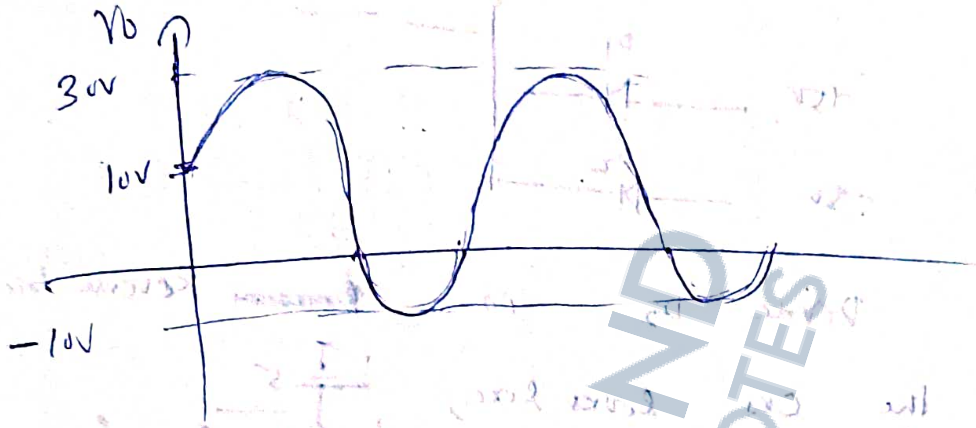
$\Rightarrow$ ~~V_1~~ $V_C = V_1' - 10 = 20 - 10 = 10V$

When diode R.B (+ve half cycle)



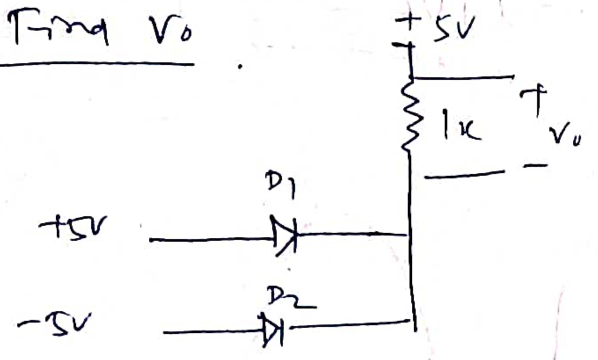
$20 + 10 - V_0 = 0$

$\Rightarrow \boxed{V_0 = 30V}$ (Sinusoidal)



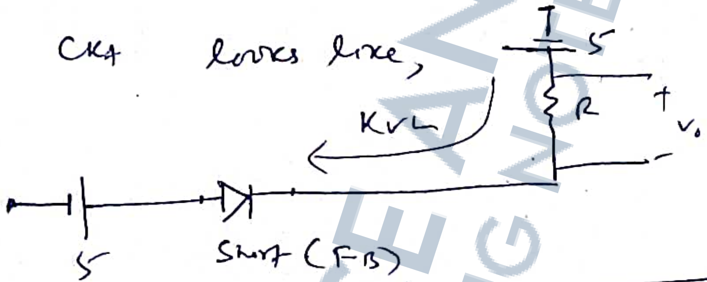
Solution to BE - Internal Question (21.02.2015)

1) (d) Find V_0



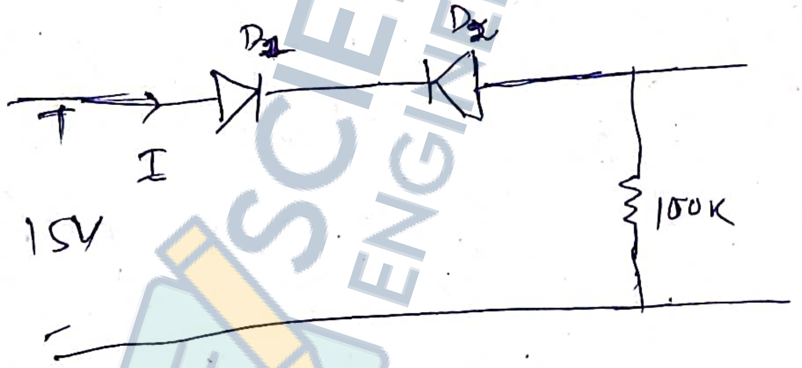
Ans: Diode D_2 is Reverse biased

So the ckt looks like,



$5 - V_0 - 5 = 0 \Rightarrow$ $\boxed{V_0 = 0}$

(f)



Find I ?

Given :- $I_s = 0.1mA$, $V_T = 25mV$, $\eta = 2$.

Supply voltage = 15V.

Ans: Here diode, D_1 is F.B.

D_2 is R.B.

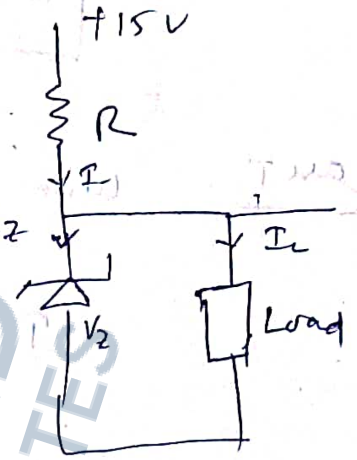
Ideally it should be open circuit,

but practically in R.B there exist a reverse saturation current.

So Current in the ckt is

$$I_S = 0.1\ mA$$

27 (b) Given



$$V_Z = 5.6\ V.$$

$$I_{Z\,min} = 1\ mA$$

$I_{Z\,max} =$ 5 times $I_{Z\,min}$

$= 5 \times 1\ mA$

$$I_{Z\,max} = 5\ mA$$

Supply = +15V.

$(I_L)_{min} = 0\ mA$

$(I_L)_{max} = 15\ mA.$

We have to find suitable values of 'R'.

~~Case I: When $(I_L)_{min}$ & $(I_Z)_{max}$~~

Always $I = I_L + I_Z$ is a const.

$I = (I_L)_{min} + (I_Z)_{max}$

or

$I = (I_L)_{max} + (I_Z)_{min}$

and $V - IR - V_Z = 0$

$\Rightarrow 15 - IR - 5.6 = 0$

$\Rightarrow IR = 15 - 5.6 = 9.4V$

$$IR = 9.4V$$

<u>Case I</u>. When $(I_L)_{min}$ & $(I_Z)_{max}$.

$I = (I_L)_{min} + (I_Z)_{max}$

$= 0 + 5$

$I = 5mA$

$IR = 9.4V$

$\Rightarrow R = \frac{9.4}{5 \times 10^{-3}} = \frac{9400}{5} = 1880$

$= 1.8 k\Omega$

<u>Case-II</u>: When $(I_L)_{max}$ & $(I_Z)_{min}$.

$IR = 9.4V$.

$I = (I_L)_{max} + (I_Z)_{min}$

$= 15 + 1$

$I = 16 mA$

$IR = 9.4V$

$\Rightarrow R = \frac{9.4}{I} = \frac{9.4}{16 \times 10^{-3}} = \frac{9400}{16} = 587.5 \Omega$

So 'R' will vary from $587.5\Omega < R < 1.8 k\Omega$

b) Max^m Power dissipation

$= V_Z \times I_{Zmax}$

$= 5.6 \times 5 mA$

$= 28.0 \text{ watt} \times 10^{-3}$

$= 28 mWatt$

3) (a)

Given $I_S = 10^{-10} A$, $\eta = 2$.

$I_D = ?$ if $V_D = 0.65 V$.

$$I_D = I_S \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

$$= 10^{-10} \left(e^{\frac{0.65}{2 \times 25 \times 10^{-3}}} - 1 \right)$$

$(\because V_T = 25 mV$ for room temp$)$

$$I_D = 10^{-10} \left(e^{12.5} - 1 \right) = 2.68 \times 10^{-5} \text{ Ampere}$$

(b)

Given $I_D = 200 \mu A$, find V_D.

$$I_D = I_S \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

$$\Rightarrow 200 \times 10^{-6} = 10^{-10} \left(e^{\frac{V_D}{2 \times 26 \times 10^{-3}}} - 1 \right)$$

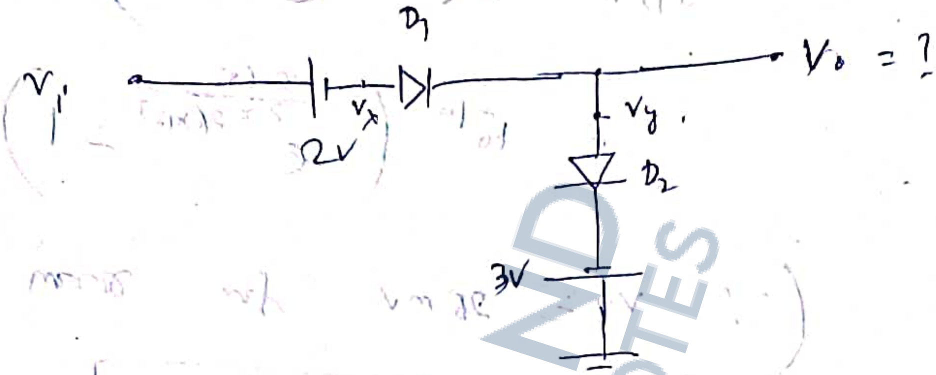
$$\Rightarrow e^{\frac{V_D}{52 \times 10^{-3}}} - 1 = \frac{200 \times 10^{-6}}{10^{-10}} = 200 \times 10^{4}$$

$$\Rightarrow e^{\frac{V_D}{52 \times 10^{-3}}} \simeq 200 \times 10^{4}$$

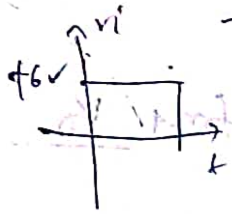
$$\Rightarrow \frac{V_D}{52 \times 10^{-3}} = \ln (200 \times 10^{4}) = 14.50$$

$$\Rightarrow V_D = 14.5 \times 52 \times 10^{-3} = 0.754 V$$

4)



Ans: For +ve half cycle

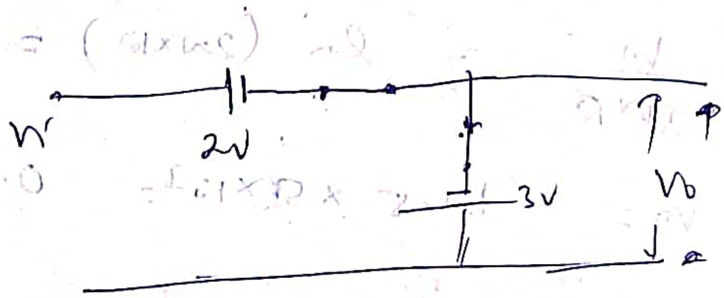


$V_x = 6 - 2 = 4V$.

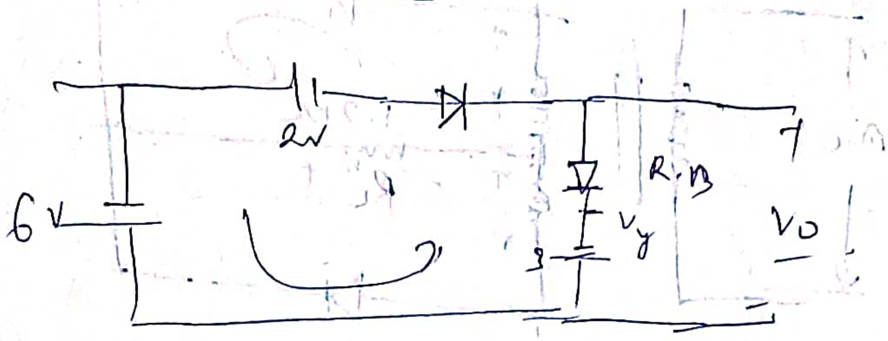
D_1 = Forward biased.

D_2 = Forward biased. [D_2 has N end -ve, P end +ve]

Vrange will be $\boxed{-3V}$



For -ve half cycle:



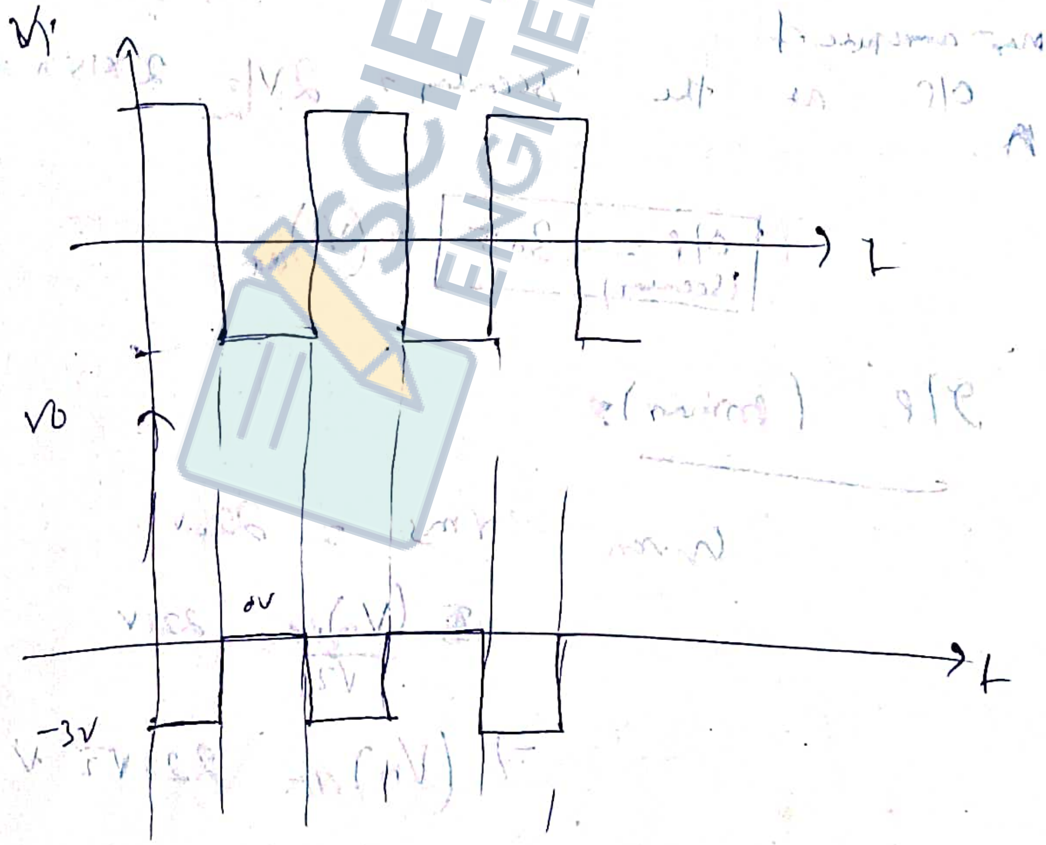
$$6 - 3 - V_y = 0$$

$$\Rightarrow V_y = 3V$$

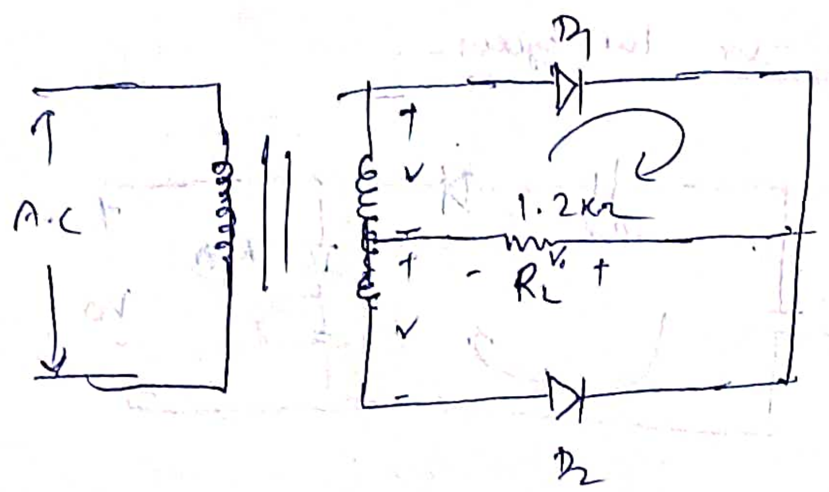
Since N is connected to +ve.

diode D_2 R.B.

$$V_0 = 0$$



5)



Given :-

$V_{dc} = 30V$ (Drop across the load R_L).

$\Rightarrow \frac{2V_m}{\pi} = 30V. \Rightarrow V_m = \frac{30\pi}{2} = 15\pi.$

$V - V_{AO} = 0 \Rightarrow (V_0)_{max} = 15\pi$

$\Rightarrow V|_{max} = V_0|_{max}$

~~$V = \frac{2V_m}{\pi}$~~ $V_{max} = 15\pi$.

Min^m amplitude of O/P at the secondary $= 2V|_{max} = 2 \times 15\pi = 30\pi$

$\boxed{O/P \text{ (secondary)} = 30\pi} = (V_m)_{o/p}$

I/P (primary)

Given $rms = 220V$.

$\frac{(V_m)_{i/p}}{\sqrt{2}} = 220V$

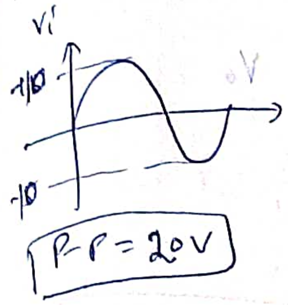
$\Rightarrow (V_m)_{i/p} = 220\sqrt{2}. V$

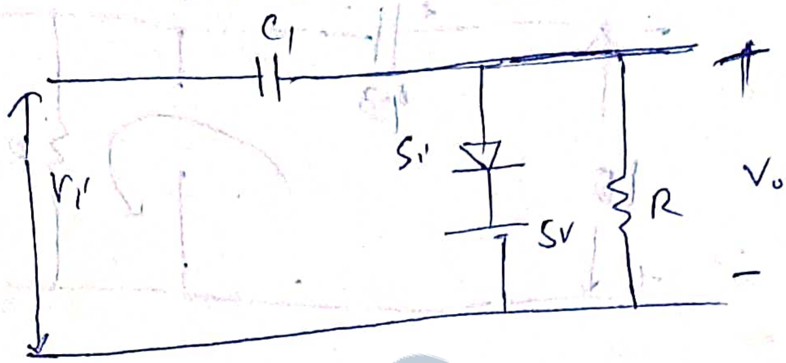
$\frac{(V_m)_{i/p}}{(V_m)_{o/p}} = \frac{n_1}{n_2} \Rightarrow \frac{n_1}{n_2} = \frac{22\cancel{0}\sqrt{2}}{3\cancel{0}\pi}$

$\Rightarrow \frac{n_1}{n_2} = \frac{22\sqrt{2}}{3.5} = 3.3$

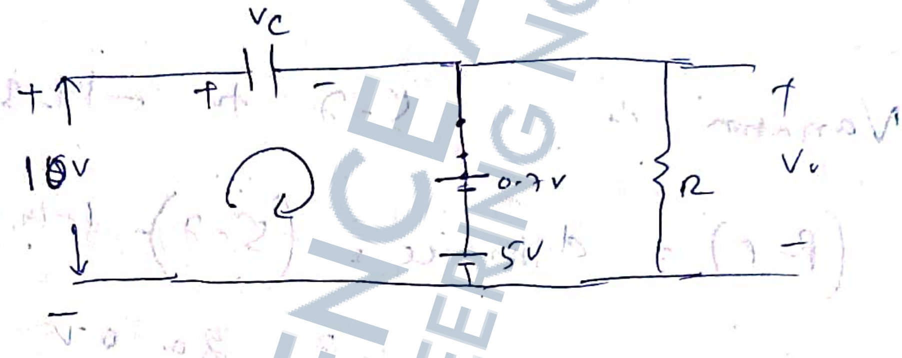
$\rightarrow$ o/p freq = 2 fin = 2 × 50 = 100 Hz

5) (a)





A: For +ve half cycle



Diode is short circuited (F.B).

Since 'Si' diode 0.7V drop occures.

~~$V_o = V_i - 5$~~ $V_o = 5.7V$

(or) $V_o - 0.7 - 5 = 0 \Rightarrow V_o = 5.7V$)

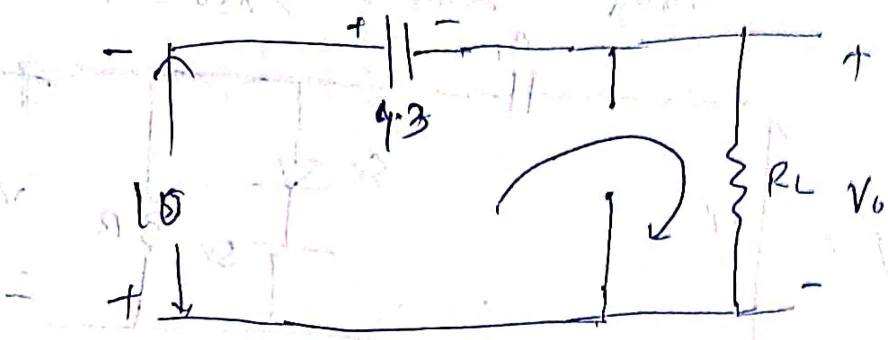
$\rightarrow$ Capacitor will charge in this cycle.

To find (V_c)

$10 - V_c - 0.7 - 5 = 0$

$\Rightarrow V_c = 4.3V$ = $-4.3V$

During -ve half cycle

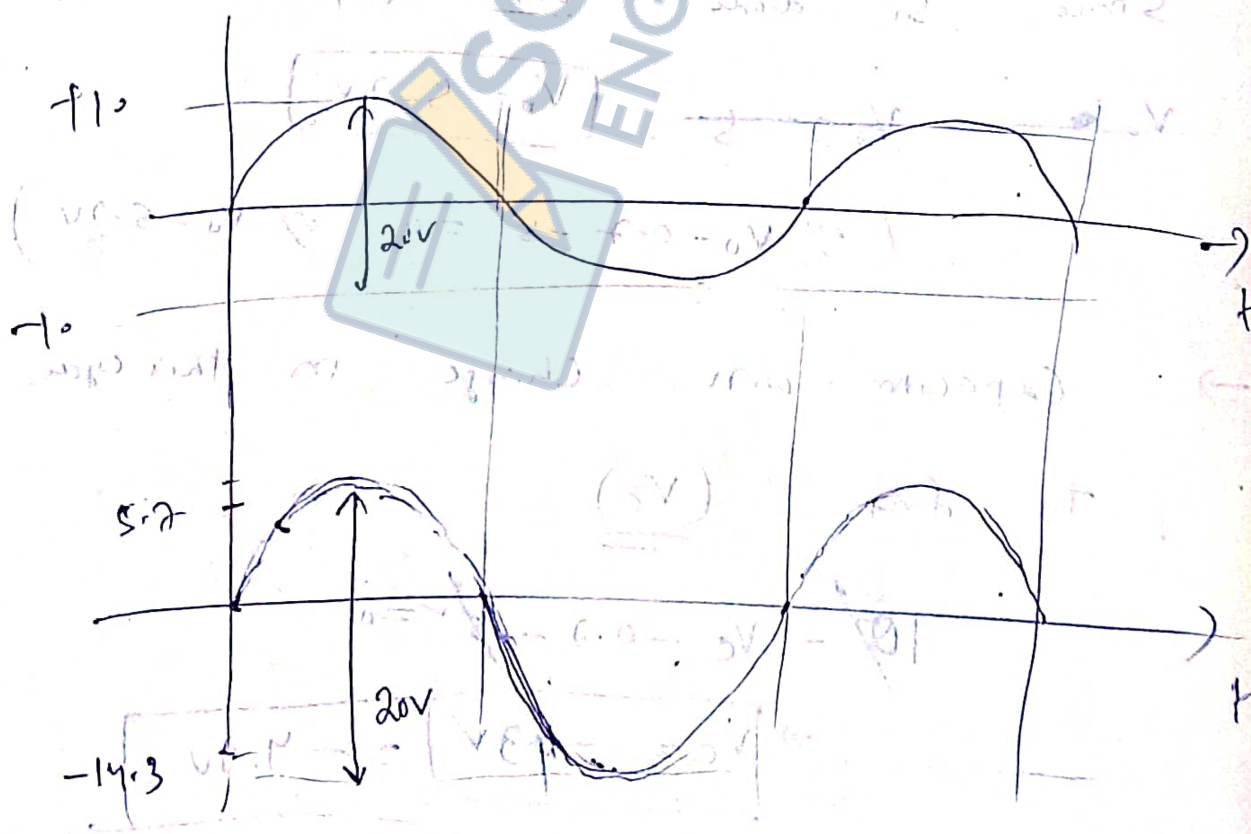


$$-10 - 4.3 - V_0 = 0 \Rightarrow V_0 = -14.3$$

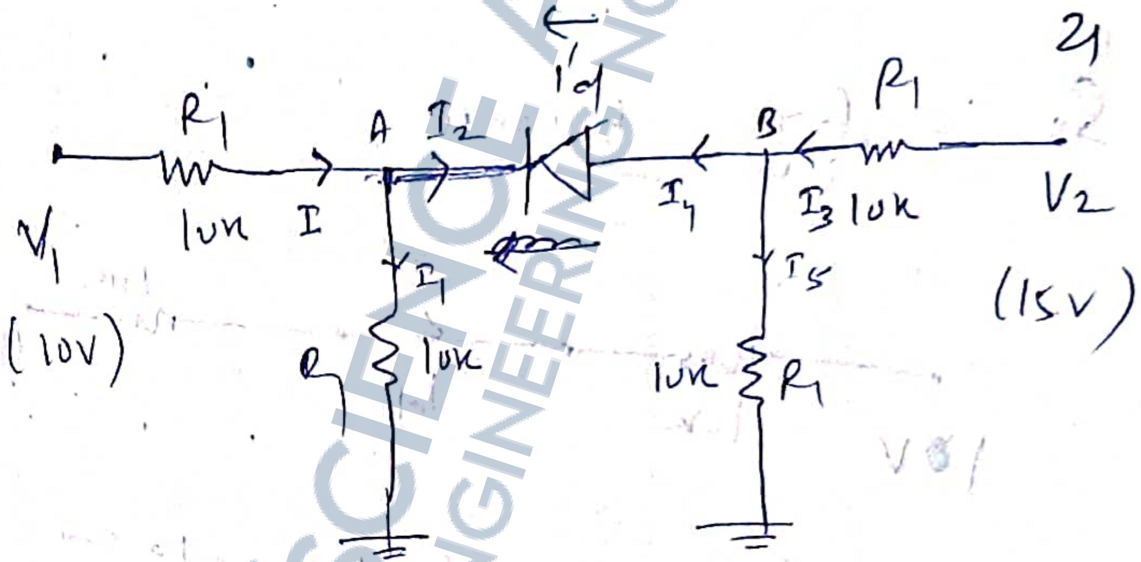
Variation is 5.7 to -14.3.

(P-P) = difference = (5.7) - (-14.3)

= 20.0 V



(b)



Using Nodal Analysis (At Point A)

$$\frac{V_1 - V_A}{10k} = \frac{V_A}{10} + I_2$$

$$\Rightarrow \frac{10 - V_A}{10k} = \frac{V_A}{10k} + I_2$$

~~$\Rightarrow 10 = \frac{11 V_A}{10} + I_2$ — (1)~~

$$\Rightarrow I_2 = \frac{10 - V_A}{10k} - \frac{V_A}{10k} = \frac{10 - 2V_A}{10k} \quad \text{— (1)}$$

At Point B

$$\frac{V_2 - V_B}{10k} = I_4 + \frac{V_B}{10k}$$

$$\Rightarrow I_4 = \frac{V_2 - V_B - V_B}{10k} = \frac{15 - 2V_B}{10k} \quad \text{— (2)}$$

→ We know

~~$V_A = V_B$~~

~~$I_2 = -I_4$~~

$$\frac{10-2V_A}{10k} = -\left(\frac{15-2V_B}{10k}\right)$$

$$\boxed{V_A = V_B}$$, Putting this in eq^n (1)

$$I_2 = \frac{10-2V_B}{10k} \quad \text{— (3)}$$

and $I_2 = -I_4$ — (4) (same magnitude & opposite direction)

Putting eq^n (3) & (2) in eq^n (4).

$$\frac{10-2V_B}{10k} = -\left(\frac{15-2V_B}{10k}\right)$$

$$10-2V_B = -15+2V_B$$

$$\Rightarrow 4V_B = 25$$

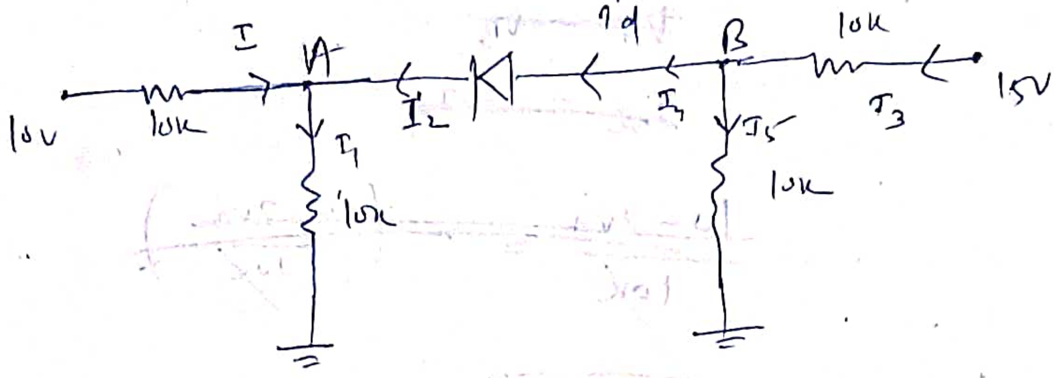
$$\Rightarrow V_B = \frac{25}{4}.$$

$$\therefore I_4 = \frac{15-2V_B}{10k} = \frac{15-2\times\left(\frac{25}{4}\right)}{10k}$$

$$= \frac{15-12.5}{10k} = \frac{2.5}{10k} = 0.25\,mA$$

$$\boxed{I_4 = I_d = 0.25\,mA}$$

Actual current direction



$V_A = V_B = \frac{25}{4}$ V.

$I_1 = \frac{\frac{25}{4} - 0}{10k} = \frac{25}{40k} = \frac{5}{8}$ mA

→ Since $V_A < 10$ volt, current flows from 10V to V_A.

$I = \frac{10 - V_A}{10k} = \frac{10 - \frac{25}{4}}{10k} = \frac{40 - 25}{40k} = \frac{15}{40k} = \frac{3}{8}$ mA.

$I_2 = r_d = 0.25$ mA $= \frac{1}{4}$ mA.

Lets check

$I + I_2 = I_1$

L.H.S

$I + I_2 = \frac{3}{8} + \frac{1}{4} = \frac{3+2}{8} = \frac{5}{8}$ R.H.S.

Similarly at Node 'B'

$I_3 = \frac{15 - V_B}{10k} = \frac{15 - \frac{25}{4}}{10k} = \frac{60 - 25}{40k}$

$V_B < 15V$

$= \frac{35}{40k} = \frac{7}{8}$ mA.

So I_3 flows from +15V to V_B.

$I_5 = I_3 - I_7$

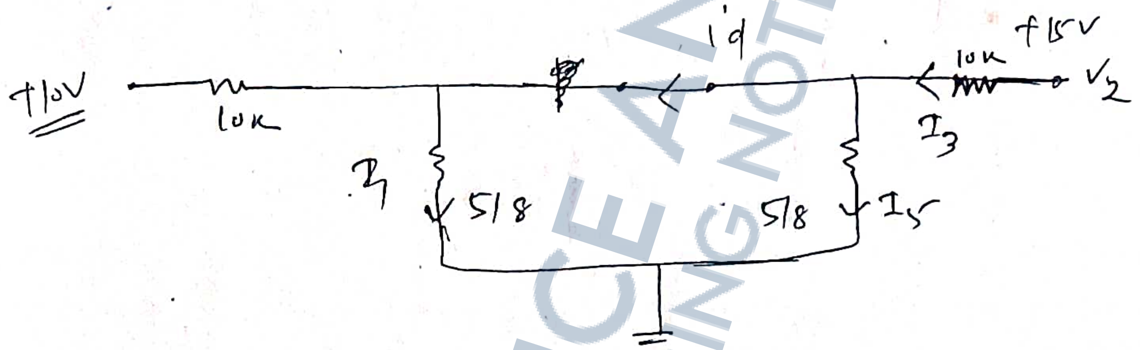
$= \frac{7}{8} - 0.25\,mA$

$= \frac{7}{8} - \frac{1}{4}$

$= \frac{7-2}{8}$

$I_5 = \frac{5}{8}\,mA$

→ If we draw the Ckt



I_7 & I_5 will cancel eachother

Net current = 0, in lower branch.

I_3 Direct

$V_2 - i'd \times 10K - i'd \cdot 10K - 10 = 0$

$\rightarrow 15 - i'd \times 20K - 10 = 0$

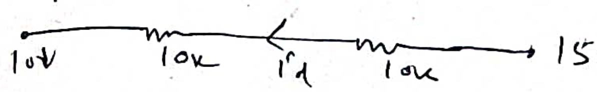
$\rightarrow i'd = \frac{5}{20K} = \frac{5}{20} \times 10^{-3} = 0.25\,mA$

Otherwise: when current I_3 comes it has 2 path, 'i'd' Path another resistive path,

current goes through 'i'd' path.

Current in the lower branch Zero.

So the ckt becomes



$$I_d = \frac{15-10}{20k} = \frac{5}{20k} = \frac{1}{4}\, mA$$

$$= 0.25\, mA$$

(Ans)